Dissertation on

AN ANALYTICAL STUDY OF THE SURGICAL OUTCOMES OF TRABECULECTOMY WITH AND WITHOUT COLLAGEN IMPLANTS

Submitted in partial fulfillment of requirements of

M.S. OPHTHALMOLOGY

BRANCH – III

REGIONAL INSTITUTE OF OPHTHALMOLOGY

MADRAS MEDICAL COLLEGE

CHENNAI – 600 003

THE TAMILNADU

DR. M.G.R. MEDICAL UNIVERSITY

CHENNAI

APRIL 2013

CERTIFICATE

This is to certify that this dissertation titled

"AN ANALYTICAL STUDY OF THE SURGICAL OUTCOMES OF TRABECULECTOMY WITH AND WITHOUT COLLAGEN IMPLANTS"

is a bonafide record of the research work done by **DR. MADANAGOPALAN. V. G**, post graduate in the Regional Institute of Ophthalmology & Government Ophthalmic Hospital, Madras Medical College and Research Institute, Chennai – 03, in partial fulfillment of the regulations laid down by The Tamil Nadu Dr. M.G.R. Medical University for the award of M.S. Ophthalmology Branch III, under my guidance and supervision during the academic years 2010 – 2013.

PROF. DR. K. MARAGATHAM. M.S., D.O.,
H.O.D OF GLAUCOMA SERVICES,
Regional Institute of Ophthalmology,
Chennai – 600 008.

PROF. DR. K. MARAGATHAM. M.S., D.O.,
DIRECTOR AND SUPERINTENDENT I/C,
Regional Institute of Ophthalmology,
Madras Medical College,
Chennai – 600 008.

PROF. DR. V. KANAGASABAI. M.D., Ph.D.,
DEAN,
Madras Medical College &
Government General Hospital,
Chennai – 600 003.

ACKNOWLEDGEMENT

I express my sincere thanks and gratitude to **PROF. DR. V. KANAGASABAI. M.D., Ph.D.,** Dean, Madras Medical College, for permitting me to conduct this study.

I have great pleasure in thanking **PROF. DR. K. MARAGATHAM. M.S., D.O.,** Director and Superintendent, RIOGOH who was also my unit Chief and guide in this study for her valuable guidance and constant support at every stage throughout the period of this study.

With profound gratitude, I thank **PROF. DR. M. RADHAKRISHNAN. M.S., D.O**., and **PROF. DR. K. VASANTHA. M.S., FRCS**., former Directors of the RIOGOH for guiding me in my initial stages at this institute and instilling an interest in the field of Ophthalmology. I am deeply indebted for their words of advice and pearls of wisdom.

I thank **PROF. DR. WAHEEDHA NAZIR. M.S., D.O.**, my unit chief for her support and encouragement in all my endeavors.

I am very grateful to my unit assistant professors, **DR. N. SHARMILA. M.S**., **DR. B. KALAISELVI. M.S**., **DR. R. MUTHIAH. M.S**., **DR. V. SHARMILA DEVI. M.S**., for their constant support and guidance throughout my period of study at this Institute. They have been responsible for all that I have learnt during this period. Their suggestions were invaluable additions to this study.

I am also indebted to all Professors and assistant Professors of this institute for the help and guidance rendered during my period of study at this Institute. I also place on record my thanks and appreciation of the work and support received from all my colleagues during my study period.

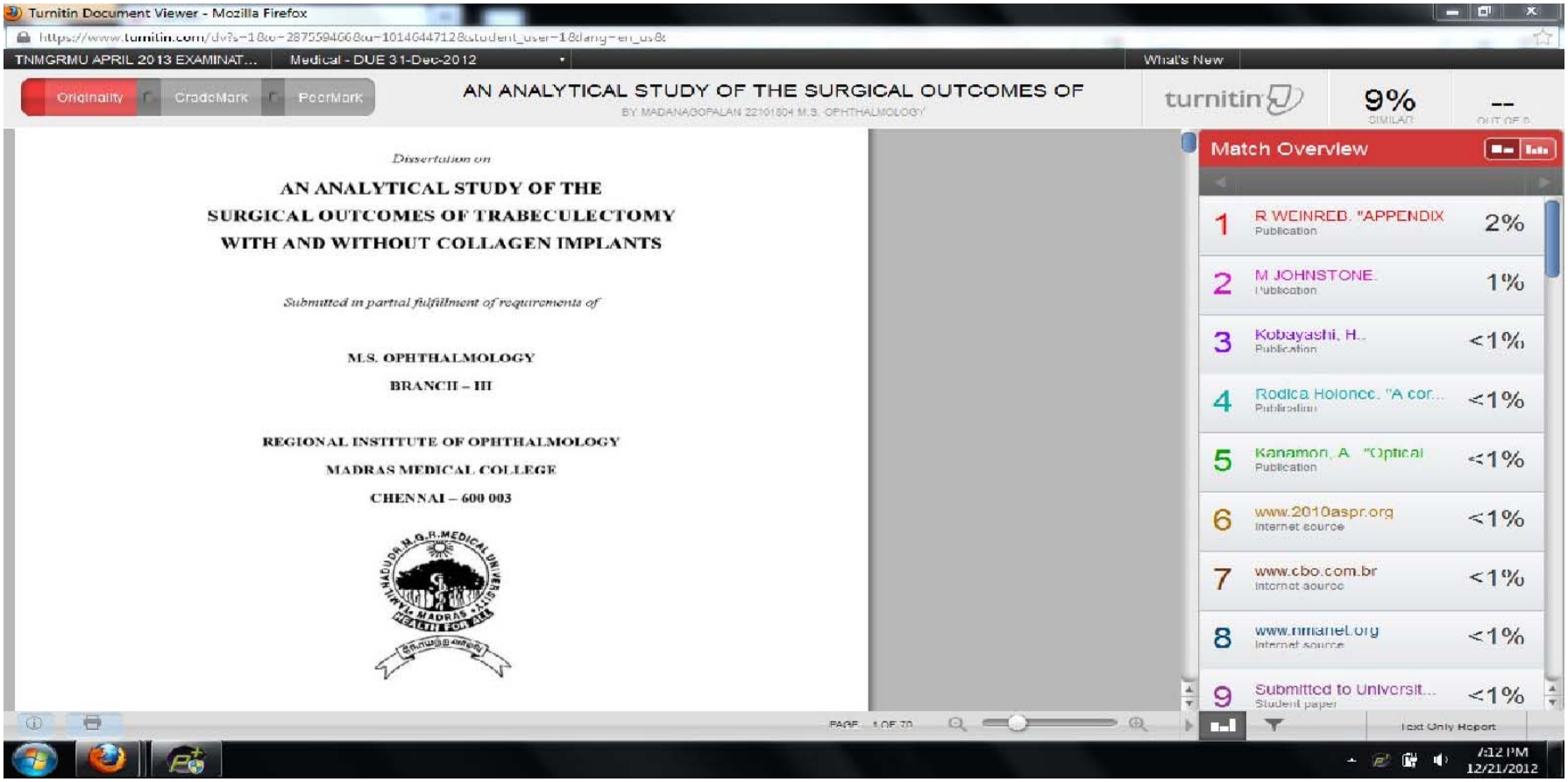
Finally, I sincerely thank all the patients for their kind consent and cooperation without which I would not be the person I am.

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled "**AN ANALYTICAL STUDY OF THE SURGICAL OUTCOMES OF TRABECULECTOMY WITH AND WITHOUT COLLAGEN IMPLANTS"** is a bonafide and genuine research work carried out by me under the guidance of Prof. Dr. K. Maragatham.

DATE :

PLACE : DR. MADANAGOPALAN. V. G


Turnitin Document Viewer - Mozilla Firefox
TNMGRMU APRIL 2013 EXAMINAT...
Medical - DUE 31-Dec-2012
What's New
Originality
GradeMark
PeerMark
AN ANALYTICAL STUDY OF THE SURGICAL OUTCOMES OF
BY MADANAGOPALAN 22101604 M.S. OPHTHALMOLOGY
turnitin
9%
SIMILARITY
Dissertation on
AN ANALYTICAL STUDY OF THE
SURGICAL OUTCOMES OF TRABECULECTOMY
WITH AND WITHOUT COLLAGEN IMPLANTS
Submitted in partial fulfillment of requirements of
M.S. OPHTHALMOLOGY
BRANCH – III
REGIONAL INSTITUTE OF OPHTHALMOLOGY
MADRAS MEDICAL COLLEGE
CHENNAI – 600 003
Match Overview
1 R WEINREB, "APPENDIX Publication 2%
2 M JOHNSTONE. Publication 1%
3 Kobayashi, H.. Publication <1%
4 Rodica Holonec, "A cor... Publication <1%
5 Kanamori, A. "Optical Publication <1%
6 www.2010aspr.org Internet source <1%
7 www.cbo.com.br Internet source <1%
8 www.rmaneLorg Internet source <1%
9 Submitted to Universit... Student paper <1%
Text Only Report
7:12 PM
12/21/2012

CONTENTS

PROFORMA

Date:

Name of the patient:

Age/Sex:

Address:

Glaucoma clinic registration number:

HISTORY

Complaints:

H/O Defective vision:

H/O Pain, halos or redness:

H/O trauma:

H/O prior ocular surgeries or Yag PI:

H/O other medical illnesses and medications:

Family H/O glaucoma:

EXAMINATION

Visual acuity:

Intra-ocular pressure (NCT):

Intra-ocular pressure (Goldmann Applanation):

Central corneal thickness:

Gonioscopy:

Cup: Disc ratio:

Automated perimetry (Loss variance):

RNFL thickness by OCT:

DIAGNOSIS:

MEDICATIONS:

SURGERY DONE:

FOLLOW-UP:

Visual acuity:

Intra-ocular pressure (NCT):

Intra-ocular pressure (Goldmann Applanation):

Central corneal thickness:

Gonioscopy:

Cup: Disc ratio:

Automated perimetry (Loss variance):

RNFL thickness by OCT:

Complications (if any):

Additional therapy (if any):

KEY TO MASTER CHART

DIA	- Diagnosis
IOP	- Intraocular Pressure
CT	- Central Corneal Thickness
CD	- Cup: Disc ratio
LV	- Loss Variance by Automated Perimetry
RNFL	- Retinal Nerve Fibre Layer Thickness by OCT
POAG	- Primary Open Angle Glaucoma
PACG	- Primary Angle Closure Glaucoma
CG	- Congenital Glaucoma
JG	- Juvenile Glaucoma
AG	- Trabeculectomy surgery
AG & O	- Trabeculectomy surgery with the OloGen implant
MT	- Medical Therapy
MMT	- Maximum Medical Therapy
RE TR	- Repeat Trabeculectomy
MTF	- Micro Track filtration with the Fugo blade
REV	- Revision of the bleb

ABBREVIATIONS

POAG	- Primary Open Angle Glaucoma
PACG	- Primary Angle Closure Glaucoma
IOP	- Intraocular Pressure
GAT	- Goldmann Applanation Tonometry
CCT	- Central corneal Thickness
AP	- Octopus Automated Perimetry
LV	- Loss Variance
RNFL	- Retinal Nerve Fiber Layer thickness
OCT	- Optical Coherence Tomography
ONH	- Optic Nerve Head
C:D	- Cup : Disc ratio
NRR	- Neuro Retinal Rim
AGIS	- Advanced Glaucoma Intervention Study
EMGT	- Early Manifest Glaucoma Trial
CNTGS	- Collaborative Normal Tension Glaucoma Study
MMC	- Mitomycin C
5FU	- 5 Fluorouracil
GDD	- Glaucoma Drainage Devices
PI	- Peripheral Iridotomy

INTRODUCTION

Glaucoma is a leading cause of irreversible blindness throughout the world. The modern understanding of the disease dates back to the mid- 19th century. However, this disease was recognised by the Greeks and Hippocrates refers to the entity as "glaucosis". World Health Organisation statistics indicate that glaucoma accounts for 13.5% of global blindness (5.1 million persons).

Glaucoma is not a single disease process but a large group of disorders with a common denominator of a characteristic optic neuropathy. Although elevated intra-ocular pressure (IOP) is the most frequent risk factor for glaucomatous optic atrophy, it is not the only factor and attempts to classify glaucoma on the basis of ocular tension are no longer valid. Nevertheless, the IOP remains a crucial parameter to the clinician as along with the aqueous dynamics, it is the only factor that can be controlled to prevent progressive optic neuropathy.

Blindness caused by glaucoma is irreversible. In nearly all cases, however, it is preventable. This requires early detection and management. There are a multitude of clinical and instrumental investigations available to help in the diagnosis of glaucoma. A clinician needs to have a thorough understanding of the disease process in order to successfully diagnose and treat the disease.

REVIEW OF LITERATURE

ANATOMY OF THE ANTERIOR CHAMBER ANGLE AND CILIARY BODY

I. Schwalbe's Line:

Schwalbe's line (composed of collagen and elastic tissue) is an irregular elevation 50–150 microns wide that runs circumferentially around the globe[1]. This line or zone marks the transition from endothelium of the trabecular meshwork to the corneal endothelium. It is marked internally by the Descemet's membrane termination. Secretory cells, called Schwalbe's line cells, are present in this area that produce a phospholipid material thought to facilitate aqueous flow[2,3].

The Schwalbe's line can be subdivided based on the histology. The anterior border adjacent to the cornea is a zone of transformation from trabecular meshwork to corneal endothelium.

The posterior border is an elevation formed due to the insertion of uveal part of trabecular tissue into the limbal stroma

II. Trabecular Meshwork

The trabeculum is a three dimensional structure. It has criss-crossing collagen fibres within the scleral canal which creates a circular channel known in ophthalmic

parlance as the Schlemm's canal. It is constituted by a connective tissue centre surrounded by endothelium. This segment can further be studied histologically. It has few subdivisions:

a. The uveal meshwork lies adjacent to the anterior chamber. It is composed of trabecular bands. These bands vary in size of openings. The openings range from 25 to 75 microns. They extend from the root of the iris and ciliary body to the anteriorly placed Schwalbe's line.

b. The corneoscleral meshwork is constituted by similar plates of trabecular tissue with ovoid pores in the range of 5 to 50 microns in diameter bridging the scleral spur to the front of the scleral sulcus

c. The juxtacanalicular connective tissue is composed of the outermost portion of the system. It is made up of connective tissue interior bordered on either side by endothelium. The outer endothelium is continuous with the interior side of Schlemm's canal thus forming the major site of resistance to aqueous outflow from the eye. The transcellular transport of aqueous has a system composed of pores and with vacuoles which establish a communication between the Schlemm's canal.

III. Schlemm's canal

The Schlemm’s canal is an endothelium lined channel like structure which is 195 to 375 micrometer in size[4]. Changes in aqueous outflow from the eye which are

dependent on gradient changes in the pressure between the anterior chamber and the schlemm's canal might occur. It is likely due to an increased resistance to the outflow of aqueous accompanied by increase in intraocular pressure which causes canal collapse.

IV. Scleral spur

The posterior border of the scleral sulcus is is an elevated whitish structure. It is formed by the sclera and insertion of the longitudinal portion of the ciliary muscle. This is composed of collagen fibers.

V. The Ciliary body band

This discrete structure is dark coloured and extends 5 mm posteriorly from the scleral spur to the insertion of the retina and choroid at the ora serrata in the posterior segment[5]. It is primarily composed of muscular tissue. Other components are blood vessels and the epithelium. This structure which forms a band presents the part of ciliary body visible on gonioscopic examination. The width of the ciliary body indicates the of the iris insertion level. Approach of iris to this band may be convex or concave. On some occasions, plateau or flat insertions may be encountered.

This ciliary body band is subdivided as follows into various parts

I. *THE PARS PLICATA* – It is formed by anterior 2 to 3 mm of the ciliary body. Its constituents are :

1.The Ciliary muscle:

- Longitudinally oriented fibers insert into the scleral spur in front. They provide an attachment for the ciliary body at the limbus. They also provide attachment to suprachoroidal lamina behind and extnd upto the equator of the eye. Hence an effect on aqueous outflow can be demonstrated when themuscle acts

- Circularly oriented fibers are present in the anterior portion of the muscle and are placed parallel to the limbal region. They play a role in accommodation

- Radially oriented fibers connect the aforementioned parts of the ciliary muscular apparatus.

2. Ciliary vessels:

- The anterior ciliary artery and long posterior ciliary arteries (2 in number) form an anastomosis close to the root of iris. These together constitute the major arterial circle.

- The supply extends to iris, entire ciliary body region and choroidal layer. They can be injured by iridodialysis and lead to hyphema.

- Venous outflow is through vortex veins and intrascleral plexus. The episcleral veinous channels play a minor role.

3. Ciliary processes:

- The pars plicata is thrown into 75 to 85 folds. Zonular fibers find attachment in the troughs formed by these ciliary processes. Few attachments are also to the pars plana. The ciliary processes have these layers:

- A. The Ciliary epithelium which is composed of two types of epithelial layers. Pigmented epithelial layer forms the outer zone. It is nearer to the stroma and consists of cuboidal cells. A prominent nucleus and melanosome granules are seen. The nonpigmented inner epithelium layer in contact with aqueous is made up of columnar cells which transform to cuboid shape in the pars plana region. Tight junctions known as the zonulae occludens constitute the blood aqueous barrier. The apices of nonpigmented epithelium are the sites of active aqueous secretion. Thus this region has many mitochondrion, endoplasmic reticulum and vesicles. Enzymes like the NaK ATPase & carbonic anhydrase are also predominant.

- B. A capillary network constitutes the center of each ciliary process. The major arterial circle supplies these capillaries. The endothelium of these vessels is fenestrated. Thus maximal permeability is allowed in this network.

- C. The stromal region is composed of a mucopolysaccharide base. Further, collagen fibers separate the capillaries from the epithelium. They constitute the main mass of the ciliary body.

II. *THE PARS PLANA REGION* – It is composed of the posterior 3 to 4.5 millimeters of ciliary body[6]. It bridges the choroid with ora serrata. Similar to the pars plicata, pigmented and non-pigmented epithelium is encountered here. The non-pigmented epithelium is the site of production of vitreous mucopolysaccharides.

GONIOSCOPY:

Visualisation of the anterior chamber angle and structures contained therein is termed Gonioscopy[2]. It can be diagnostic or therapeutic.

One cannot see the angle structure directly due to total internal reflection. This physical phenomenon occurs at the cornea to air interface. The critical angle for this interface is 47^{o}. Instruments which aid in this procedure are the Goniolenses. They have a refractive index similar to the cornea. Hence, the optical effect of total internal reflection is removed from the system.

Light emanating from the cornea is seen by two basic mechanisms which form the basis of the types of goniolenses:

- Direct gonioscopic examination needs the patient to be supine. Refraction of rays at the lens to air interface occurs. The examiner needs a light from outside to aid the visualisation. A few examples are the Koeppe, Swan Jacob, Thorpe and Barkan lenses.

- Indirect gonioscopic examination can be performed with the patient sitting. Here light rays coming from the chamber angle are reflected. The instrument uses a mirror for this purpose. Examples are the Goldmann mirrors and Zeiss gonioscopes. Some instruments are known as indentation gonioprisms. They enable distinction between appositional and synechial closure of the angle. Examples are the Zeiss and Posner lenses.

OPTIC NERVE HEAD ANATOMY

The optic nerve is the second cranial nerve. It is constituted by 1.2 to 1.3 million axons[7]. The axonal processes are derived from the cell bodies of the retinal ganglion cells. The RGC axons from all parts of the retina converge upon the optic nerve head. On the optic nerve head surface, axons of RGCs take a sharp turn and leave the globe by passing through the fenestrated lamina cribrosa formed by the sclera[2,3]. These axons constitute the visual pathway. They lead on to the optic nerve and chiasm. From there, optic tract runs backward and synapses at the lateral geniculate body which is a

part of the thalamus. Further course of the visual pathway is via the optic radiation and finally terminates at the cortex of the occipital lobe.

The term “optic nerve head” (ONH) refers to the distal part of the optic nerve which is ovoid in orientation. The structure has a three dimensional orientation. The extent can be traced from surface of the retina to the sclera lamina cribrosa. The ONH is the site where RGC axons leave the eye. It is seen 3.5 – 4.5 mm nasal to the fovea. The main constituents are neural tissue elements, collagen support and few blood vessels in the substance. The ONH is 1.5 millimeter in width. It is normal to observe a large variation in this size within a normal population. The central part of ONH has a small depression. It is referred to as the optic cup. It represents a portion of the ONH with relative paucity of axons. The neural elements between the cup marin and the disc is known as the neuroretinal rim (NRR).

Degeneration of the axons of the NRR is seen as thinning of the rim and characterises the various changes seen in glaucomatous optic atrophy. These changes in the neural rim of glaucoma affected eyes cause optic cup enlargement with subsequent field loss. The cup : disc ratio (C/D) an indicator of NRR. This could be erroneous when the bigger nerve head may contain an enlarged cup. There could also be a decreased NRR width inspite of a normal of neural tissue on the ONH. The NRR is characteristically broad over the inferior sector of the disc. This is followed by the superior NRR and the nasal side. The temporal side if the disc has the thinnest NRR. This typical arrangement is often referred to as the ISNT rule.

Various studies that employed stereoscopy have shown a mean c:d of 0.4 in very few eyes (around 5%). However, a 0.7 disc or larger or a c:d difference of more than 0.2 between two eyes occured only in 2% of the normal population. The size of the cups may be a manifestation of multifactorial patterns of heredity. Studies also show a larger disc and C/D in black patients. This is important as glaucomatous optic atrophy shows a progressive and asymmetric loss of NRR.

There are no photoreceptors on the ONH. Hence it corresponds to a blind spot in the visual field. The size is a 5.5 to 7.5 degree scotoma. This is known as the blind spot of Mariotte and is located temporal visual field.

Subdivisions of the ONH:

- The nerve fiber layer (NFL): The retinal nerves enter the optic nerve in a particular pattern. This pattern is responsible for the various nerve fiber layer and consequent field defects. The retinal nerve fibers originating in the temporal retina arise on both sides of a horizontally oriented line. This is known as the median raphe. Fibers then arch superior and inferior to the fovea in an arcuate manner and are called the arcuate fibers. Arcuate nerve fibers which enter the superior and inferior poles of the ONH are more susceptible to damage in glaucoma. The papillomacular fibers from the fovea and fibers from nasal retina take a more direct route to the optic NH. All these retinal fibers are visible ophthalmoscopically as striations over the retina around the

ONH. The RNFL is primarily supported by the retinal astrocytes. It receives a vascular supply from the central retinal artery.

- The Prelaminar portion of the ONH: This part is clinically visible as a central depression called the optic cup and contains axons and glial supporting elements. Blood supply originates from the short posterior ciliary system of vessels. Minor branches from the surrounding choroid are also seen.

- The lamina cribrosa: Deep to the prelaminar part, fenestrated sheets of sclera are arranged in around 15 plate like structures with about 500 to 700 pores which permit bundles of neuronal elements to leave the ONH. Blood supply is from the short posterior ciliary system of vessels that form the arterial circle of Zinn.

- The retrolaminar region: The part of the ONH which lies posterior to the lamina cribrosa is the retrolaminar region. It is primarily extra ocular. It is characterized by the myelinisation of axons that exit the lamina cribrosa. The myelin of the nerve is produced by oligodendrocytes. Thereafter, the diameter of the nerve increases to double its size. Blood supply is from the branches of the meningeal artey and the central retinal artery. Hence the retrolaminar region receives supply from both ciliary system and retinal circulations.

AQUEOUS HUMOR DYNAMICS

Intraocular pressure maintenance and thus the study of the pathology of glaucoma is dependent on the aqueous humor and its dynamics. Aqueous is primarily derived from the blood plasma[8]. Plasma from within the ciliary process capillary network is converted to the aqueous of the anterior chamber by three distint physiologic processes:

1. **Diffusion**- The lipid soluble substances diffuse through the lipid constituted parts of the ciliary process cell membrane. The rate at which the process occurs is dependent on the concentration gradient of the same substance on both sides of the membrane.

2. **Ultrafiltration** – Apart from diffusion, the addition of water and water soluble substances to the aqueous by this process. It is dependent on size of the substance and its charge. Flow in one direction via small pores in the membrane of the cell occurs secondary to an osmotic gradient. The hydrostatic pressure across the barrier also plays a role. Some other factors are intraocular pressure, ciliary capillary blood pressure and oncotic pressure of the plasma. These are passive transport mechanisms and limited by the presence of tight junctions between the nonpigmented ciliary epitheliaum.

3. **Active transport**: This process is also termed secretion. Larger substances which are water soluble and with more charge are transported by this modality. It is an active process and needs energy. NaK ATPase enzyme and enzymes of glycolysis are seen in the nonpigmented epitheliaum. They bring about active secretion. It is decreased in hypoxic conditions, and hypothermia. This method of active transport causes the major bulk of aqueous production.

The rate of formation of aqueous humor is 2.0 to 3.5 microliter per minute. Aqueous then enters the posterior chamber. The volume of aqueous in this region is 0.06 ml. Aqueous then enters the anterior chamber passing through the pupil. The volume of aqueous in the anterior chamber is 0.25 ml.

Aqueous outflow from the anterior chamber is by three routes: the trabecular, uveoscleral and uveovortical pathways

1. **Trabecular outflow**: about 85 to 95% of the aqueous humor leaves the eye by the trabecular pathway. Hence, the trabecular outflow is the major route of aqueous outflow. Aqueous resistance is encountered at the juxta-canalicular region and the inner wall of the Schlemm's. Further transport of aqueous across these structures is done by a process vesicles or vacuole formation. Studies have shown that this is a passive transport dependent on pressure.

2. **Uveoscleral outflow**: Aqueous also flows out through the ciliary body and root of iris to ciliary muscle to enter the suprachoroidal space. Further drainage is through the veins in the ciliary body or choroid. This is a relatively minor outflow route which is enhanced by cycloplegic drugs, adrenergic agonists and by inducing cyclodialysis. This outflow is lesser on using miotics. In contrast to the trabecular outflow, this route is relatively independent of pressure changes.

3. **Uveovortical outflow pathway**: Studies have shown discernable quantities that traverse iris vessels, ciliary muscle and anterior segment of the choroid. This pathway finally exits through the vortex veins.

AQUEOUS HUMOR COMPOSITION:

The aqueous is always compared with the plasma. So in comparison, the aqueous is:

1. Hypertonic and acidic
2. Increased ascorbate levels which are 10 to 15 times that in plasma
3. Paucity of proteins .0.02% proteins compared to the 6.5 to 7% of plasma.
4. Increased concentration of chloride and lactate.
5. Decreased levels of sodium and bicarbonate.
6. Decreased concentration of glucose carbon dioxide.
7. Protein levels are equal to that in serum when a turbid aqueous is encountered in cases of uveitis.
8. Albumin: globulin ratio in aqueous is vey much like that in plasma. Immunoglobulins in aqueous are a little lesser.

AQUEOUS HUMOR FUNCTIONS:

1. Maintenance of the IOP.
2. A source of glucose and oxygen along with other electrolytes needed for the metabolic activities of cornea and lens
3. Serves to eliminate the products of metabolism

FORMATION AND EGRESS OF AQUEOUS:

- Aqueous formation falls during sleep (drop of around of 40%). It also decreases with increased age(about 2% for every 10 years), inflammation, retinal and choroidal detachment. Recent studies have shown that aqueous formation is relatively pressure insensitive and does not decrease with increase in IOP as was believed earlier.

- Parasympathomimetic drugs lead to a contraction of the ciliary muscles. This increases the trabecular and decreases the uveo-scleral outflow. Cycloplegics which lead to a relaxation of ciliary muscles causes a drop in the trabecular outflow while increasing the uveoscleral outflow of aqueous.

DEFINITION OF INTRA-OCULAR PRESSURE (IOP)

The consensus definition of normal IOP is that it is the pressure within the eye which does not result in glaucomatous damage[2, 8]. The mean IOP in a normal population is 15.6 mm of Hg when using Schiotz tonometer and 16 mm of Hg when using the Goldmann applanation tonometer. The distribution of IOP is not strictly in accordance with Gaussian principles. It is skewed towards higher values. When measuring the standard deviation, a value of 2.5 mm of Hg is obtained. Two standard deviations from the mean includes 95% of a Gaussian distribution below 21 mm Hg. Hence, the upper limit of normal is not entirely correct from a statistical point of view as the Gaussian curve is skewed. However, for practical purposes, 21 mm Hg is considered a safe limit.

Factors influencing the intraocular pressure:

- Genetically multifactorial inheritance has been described.
- There is an increased IOP within older age group.
- In the age group of 20 - 40 years the IOP is comparable in males and females. At advancing age, the mean IOP is slightly more in females
- Myopia and increased axial length of the globe are associated with higher IOP.
- Race - IOP is slightly higher in blacks when compared with whites
- The diurnal variation of IOP has been attributed to plasma cortisol level and its changes during the 24 hour period. The maximum IOP is seen in the morning hours. Variations are seen within a normal population.

- Influence of posture: IOP progressively increases when the patient goes from sitting to supine position. It increases further if legs are elevated and the head is brought down. All these effects are more pronounced in glaucomatous eyes
- Valsalva manoeuvre elevates the IOP as it causes an increase in the episcleral venous pressure (EVP).
- Blink and lid squeeze can also lead to considerable IOP increase.

METHODS TO MEASURE THE IOP:

TONOMETRY:

The principle used here is to relate a force needed to deform the globe to the pressure inside the globe. Many different models are available.

A. INDENTATION TONOMETRY

The most popular one is the Schiotz tonometer. Its footplate rests on the cornea whilst a plunger of specified weight causes an indentation on the cornea which is measured by a movement of the needle on a calibrated scale. A truncated cone is formed as a result of this deformation.

The fallacy with this instrument is that the indentation itself raises the IOP from Po to Pt. Hence an estimate of Po is always dependent upon another variable, the ocular

rigidity. It can be understood that a low ocular rigidity (denoted by ‘k’) shows a false low IOP. Low ocular rigidity occurs in high myopia, therapy with miotics, prior surgery in the eye, vasodilator drug usage, compressible gas used intravitreally, collagen disorders like osteogenesis imperfecta and endocrine disease like thyroid disorders. Similarly, a high ocular rigidity shows a false high IOP measurement. Causes for this condition are high hyperopia and therapy with vasoconstrictor agents.

Apart from these, there are other sources of error like expulsion of intraocular blood during indentation leading to lower IOP. Steep or thick corneas tend to displace more than normal fluid during indentation. This results in a false high IOP reading. In this context, the Moses effect is described wherein the cornea moulds into the small space seen around the plunger and within the opening in the tonometer footplate. This pushes the plunger up further and yields a false high IOP measurement.

B. APPLANATION TONOMETRY

The most widely used instrument is the Goldmann tonometer. It is considered to be the gold standard for IOP measurement. It works on a modification of Imbert Fick law. This law is applicable only for infinitely thin and dry spheres. It states that:

Pressure = Force/Area

Force = Pressure x Area

In other words, the external force applied on a sphere is the product of pressure inside the sphere and the area of the sphere flattened (applanated) due to this external force. A basic prerequisite for this law is that the object should be perfectly spherical, dry, infinitely thin and very flexible. The eye does not satisfy these prerequisites. Thus a modification of this law is made:

Modified Imbert Fick Law:

Force + Surface tension = Pressure x Area + Force needed to bend the cornea

If the area is 7.35 mm^2 the surface tension equals the force needed to bend the cornea and thus the external force is equal to the pressure within the eye. An area of 7.35 mm^2 equals a diameter of corneal applanation of 3.06 mm. When such a small applanating head is used, a minute aqueous volume (about 0.5 mm^3) is displaced. Thus Pt is not very different from Po and ocular rigidity (k) does not have a prominent role.

There are few sources of error whilst using the applanation tonometer. False high IOPcan be obtained with wide mires, thicker cornea, astigmatism (a factor of of 1 mm Hg for every 3 dioptre rise of corneal power), squeezing of lids, holding the breath, collars that are tight or Valsalva manoeuvre. In a similar way, false low IOP readings may be seen when applanation is performed without fluroscein, in cass of edema of cornea, and inadvertant prolongation of corneal contact. The method employed in case of marked astigmatism is to take an average of the vertical and horizontal

readings. Another method will be to align the red line on the head to the lesser curved meridian.

The Goldmann tonometer is one which uses variable force. There are other tonometers which use variable force:

- Perkins tonometer is a hand-held instrument. It resembles the Goldmann tonometer in its usage methodology.
- Draeger tonometer uses an electric motor to provide a force needed for applanation.

- Mackay-Marg tonomter measures the force needed to maintain the flat foot plate of its plunger flush with its sleeve against the pressure used for deformation of the cornea. The instrument gives higher values than the Goldmann tonometer. Nevertheless, this is an accurate instrument in eyes having irregular or scarred corneas. Mackay Marg principle is used in many new tonometers like the Tono-Pen.

- Tono Pen is an instrument where the probe causes an indent on the cornea. The IOP and reliability of readings are found by a microprocessor at the tip.

- Pneumo tonometer: A pressure sensor monitors the air pressure corneal deformation is transferred to surrounding structures. This is then related to the

IOP. Measurements thus obtained are a more thn those seen with the Goldmann tonometer.

C. NON-CONTACT TONOMETRY:

The instrument uses a puff of air to deform the cornea. This uses a constant force. The time taken from a reference plane to the flattening of the central cornea is related to the force needed. It is then calibrated to give a digital display as the IOP.

The interval between subsequent measurements is 1 to 3 msec. The measurements are done in an instant and so fluctuation of readings can be seen. It is thus necessary to take 3 radings for each eye and calculate the mean. The readings correspond to IOP by Goldmann tonometer in the normal range of IOP. The reliability reduces with higher levels of IOP.

D. CONSTANT FORCE APPLANATION TONOMETERS

The Maklakov tonometer determines the IOP measuring an area of corneal flattening using a predetermined weight.

GLAUCOMATOUS DAMAGE OF THE OPTIC NERVE HEAD

THEORIES RELATED GLAUCOMATOUS OPTIC NERVE HEAD CHANGES:

Manifestations of ONH changes in glaucoma are purely mechanical alterations due to increased IOP[9]. An increase in the IOP causes to inhibition of both the retrograde and orthograde transport within the axons at the lamina cribrosa level. It also leads to compression of the axons with resulting compromise.

1. Vascular collapse causes ischemic changes due to intraocular pressure increase or coexistant vascular pathology causes obstruction of flow of axoplasm contents and subsequent axonal loss.
2. Vascular & mechanical factors may exist in the same individual.

MICROSCOPIC CHANGES ASSOCIATED WITH GLAUCOMATOUS OPTIC ATROPHY:

Neuroretinal rim loss of the ONH which is seen as enlargement of the cup is due to axonal loss and alterations of capillary network and glial support. Loss of tissue begins at the lamina cribrosa level. It is brought about by compact comprssion and fusion of the plates of lamina cribrosa. A loss of 25 to 35% of total axons is needed before visual field loss is detected.

Loss of axons could be generalized. But characteristic findings are localised loss at the superior and inferior poles of the NRR. This is because the axonal density reaches a maximal limit in these areas. Another reason of selective damage here is that large sized retinal nerve fibers which are located greater concentration over the superior and inferior poles are mechanically more susceptible to damage by elevated IOP.

As compared to adults, cupping in glaucoma occurring in infants or children is relatively reversible. This is brought about by an expansile ring of sclera tissue in younger ages. Glaucoma when progressing causes a collapse in the plates of the lamina cribrosa. This then leads to a bowing of the lamina posteriorly.

Another distinct kind of optic atrophy which creates empty cystic spaces is given the name of Schnabel's cavernous atrophy. These spaces stain with special stains for acid mucopolysaccharide substances like hyaluronic acid. This discrete phenomenon is reported to occur with IOP elevations that are severe and also in atheromatous changes of vessels associated with a normal IOP.

MACROSCOPIC CHANGES ASSOCIATED WITH GLAUCOMATOUS OPTIC ATROPHY:

Changes in the visual field often follow changes in the optic nerve head. Stereoscopic evaluation of the optic nerve head is essential to unmask the subtle contour changes.

Documentation of these changes by stereophotography will help in progression monitoring.

I. Focal signs of glaucomatous damage are an enlarged cup focally due to localised atrophy or notching of NRR. Nerve fiber defects may be localized or diffuse and are often seen with the ophthalmoscope. Localised pallor of cup with cup changes can occur as cupping due to glaucoma can predate pallor. Drance hemmorhages on the nerve fiber layer occur frequently in normal tension glaucoma. Saucerisation of disc causing a vertical cup elongation and progression of localized neuroretinal rim loss are probable signs.

II. Generalized signs like an enlarged c:d ratio with asymmetry of cupping and progressively enlarging cup concentrically.

III. A few less specific changes are the laminar dot sign with increased cup depth or a displacement of the vessels on the cup nasally and circumlinear vessels baring wherein these vessels do not turn near the cup outline but instead are bared from the disc margin. A peripapillary atrophy can also set in.

FACTORS DETERMINING THE DAMAGE DUE TO GLAUCOMA:

- Intraocular pressure levels
- Older age groups
- Associated cardiac complications & coexistent vascular pathology
- Hereditary factors
- Scleral aperture size
- Systemic comorbidities like Diabetes mellitus
- Myopia

REVERSIBILITY OF GLAUCOMATOUS CUPPING

- Infants and children may show reversibility in cupping caused by glaucoma when surgical control of IOP has been achieved in the first year itself.
- Some reports suggest glaucomatous cupping reversal in adults. These are not very significant and could occur in early stages of atrophy when significant IOP reduction has been achieved by surgery.

THE ROLE OF PERIMETRY IN VISUAL FIELD LOSS ASSESMENT IN GLAUCOMA:

The visual field is described as the part of the external three dimensional space which is simultaneously perceived by the eye that is fixating on a particular target. The normal visial field is 60° in superiorly, 75° inferiorly, 110° over the temporal field and and 60° in the nasal field. The visual fields were described as an island hill of vision in an ocean of darkness by Traquair. The area of maximal sensitivity when the retina is in light adapted state is represented by a central peak which corresponds to the fovea of the eye[10].

Deviations from the shape of the normal line which marks the visual hill that are statistically and clinically significant may be taken as a field of vision defect. Patterns in apatient who has glaucoma may be some diffuse depressions or localized defects. The local defects in glaucoma follow a pattern of the nerve fibers loss which is restricted to certain areas. In contrast, diffuse depression shows a generalized loss of sensitivity throughout the retina and occurs subsequent to loss of retinal axons in a more diffuse and generalized fashion. When compared to local defects, diffuse loss of field is relatively less specific for glaucoma damage since it can occur in other ocular affections.

A cataract is most often a reason for diffuse depression of the field. A miotic pupil refractive errors, fatigability of the patient or a first automated field examination are

also likely causes of generalised field depression. Hence, depression of fields in a diffuse manner cannot be specifically attributed to glaucoma.

RNFL damage in particular areas of the retina and the ONH when a glaucomatous process is ongoing will result in certain characteristic local field defects. These local defects tend to correspond with the anatomic distribution of the nerves in the retina. Paracentral well defined defects occur early in any damage to the RNFL by glaucoma. Such a defect could be absolute at presentation. More often, areas of depressed sensitivity surrounded by more sensitive areas are encountered[11].

If the loss of axons proceeds unchecked, arcuate fibers of the retina are then involved. This manifests as scotoma called the arcuate scotoma. It begins near the blind spot on the temporal visual field and arches around fixation to end at the horizontal meridian on the nasal side of the field. Following the anatomic distiribution of the nerve bundles, the defect is narrow temporally and fans out nasally to occupy a relatively larger space.

As mentioned earlier, all arcuate scotomas will terminate at the horizontal plane on the nasal side of the visual field. RNFL loss in the inferior and superior fields is not often symmetrical. If there is any disparity in their horizontal extent at their junction along the raphe, it manifests as a defect called the nasal step. Arcuate scotomas and paracentral scotomas are often associated with the nasal step. In about 20%, apart

from other scotomas, nasal steps occur alone. Peripheral nasal step defects are the first presentation in round 8% of patients.

A few other characteristic field defects occur if the nasal retinal fibers are involved. Though the superior and inferior poles are most commonly involved in glaucoma, nasal part of the ONH can sometimes be involved. This then leads to damage to the radial nerve fibers in the nasal retina. Loss of these fibers manifest on the visual fields as wedge defects temporally. Unlike the nasal arcuate defects, these temporal wedge defects do not respect the horizontal meridian. In around 2% - 3%, they are the only field loss demonstrated.

EARLY FIELD CHANGES – Studies have shown that the most common defects are nasal steps and paracentral scotomas. They occur in around 54% and 41% respectively. It is also likely that these defects coexist. Arcuate defects and blind spot enlargement sre the other common defects which are seen in 20 and 30% respectively. Temporal defects are less common and occur in 2 to 3%. It is important to note that an early field loss could be either relative or absolute.

BLIND SPOT CHANGES - Siedel scotoma is an enlargement with an elongation of the blind spot vertically. Early arcuate defects that are contiguous with the blind spot and extend either above or below the horizontal meridian are seen. Blind spot enlargement is attributed to the phenomenon of peripapillary atrophy that sets in with

advancing glaucomas. Physiologic or pathologic baring of the blind spot may also be encountered.

GLAUCOMA PROGRAMS ON THE AUTOMATED PERIMETER- The G1 program or 32 is very similary to the 30 – 2 program on the Humphrey's perimeter. They test the central 30° of the field with a 6° separation between each tested point along the horizontal or vertical meridians. 24-2 program on the Humphrey eliminates testing of the edge points from the 30-2 program apart from the areas of nasal step. It checks only the central 24°. It is better than the 30-2 as the edge point data are nor very reliable and are influenced by external factors.

RETINAL NERVE FIBER LAYER THINNING AND THE ROLE OF OCT:

The principle behind the working of the Optical coherence Tomography (OCT) is low coherence interferometry.

Interferometry is done using a white beam (ie., low coherence light). By the use of such light rays, images and measurements can be done at high resolution. The resolution of latest machines available in the market range from 10 to 20 microns. The instrument basically compares the properties of light reflected from the retina with a reference beam. The interferometer is using in the process of comparing the two light beams[12].

- RNFL thickness can be measured with OCT. It is very useful in glaucoma diagnosis and detection of progression of the disease.
- Identifiable retinal nerve fiber layer thinning occurs before field defects and obvious cupping set in.
- RNFL thinning correlates with visual field defect and NRR loss in the more advanced stages of the disease whereas RNFL thinning seems out of proportion to field loss in early stages of glaucoma. Early glaucoma detection is possible with monitoring of the RNFL thickness and NRR.
- Glaucoma cannot be identified based on the local thickness of RNFL. Many age related and individual factors play a role in their location and extent.
- As a general rule, the RNFL is thick inferiorly and superiorly in normal eyes. In a glaucomatous eye, it is more likely to be thinned out and flatter.
- The nasal retina is the least likely site of glaucomatous damage.
- Similarly other ocular anatomic variations (eg., Myopia) tend to affect the temporal retina. So the nasal retina is relatively spared.
- The distance from margin of the disc is inversely related to the thickness of the RNFL.

INDICATIONS FOR SURGERY

The surgical decision needs to consider the risk : benefit for the patient. A lower IOP is beneficial to the eye but the loss of vision is a risk. So saving vision with surgery must be paramount[13, 14].

Surgery for glaucoma is indicated if:

- Medical therapy fails to lower the IOP.
- Laser surgery is not beneficial
- The compliance with medical therapy is likely to be poor.

1. Physicians should check IOP more than once and various times of the day when calculating the baseline IOP before surgery. If IOP is markedly increased, a single determination may be enough.
2. Glaucoma Progression taking both the structural and functional integrity of the optic nerve should be kept in mind.
3. Further care of the glaucoma patient needs careful periodic evaluation of structure and function of the optic nerve.
4. Estimating the rate or risk of progression is needed. Age should be considered when planning treatment. An older patient with minimal progression may suffer no effect on quality of life during his life.
5. Risk factors associated with glaucoma progression are found from prospective studies[15]. The AGIS has showed that older age, males, lower education, diabetic status are a risk. Similarly, CNTGS showed that females and migraine are risk factors. The EMGT uncovered higher IOP, pseudo-exfoliation, visual fields progression during follow up, haemorrhages over the disc as risk factors. These risk factors will change the target IOP or lower the threshold for surgery[16, 17].

6. Loss of vision in the other eye from glaucoma lowers the threshold IOP for surgical consideration. Family history of glaucoma will require a close observation of the patient.
7. Surgery as a primary treatment is indicated based on some socioeconomic or logistic reasons. All patients need not undergo primary surgery.
8. Compared to those with early disease, those patients with central field loss need early surgery.

GLAUCOMA SURGERIES:

Glaucoma drainage procedures which are also known as external filtration surgery is performed in case there is no flow block internally and the IOP remains high inspite of using maximal medical therapy. Two types of these filtration procedures are described. They are the guarded and full-thickness procedures. Other changes to the basic steps are being followed of late.

GUARDED FILTRATION PROCEDURE (TRABECULECTOMY):

This is the procedure of choice in hitherto unoperated eyes. Suture modification for further IOP adjustment is now being employed.

Trabeculectomy offers better and long term IOP lowering than NPGDS. Use of anti fibrotic agents should be based on individual case profile. This is relevant to initial

and repeat surgery. Presurgical inflammation of the conjunctiva and postsurgical inflammation of the conjunctiva and ocular contents should be controlled with steroids. Success of trabeculectomy depends on postsurgical care. Early recognition of complications and prompt intervention increases the success of the procedure. Late bleb related infection is a serious threat and patients need to be warned about them. Immediate attention in these cases is important for visual prognosis.

TRABECULECTOMY TOGETHER WITH CATARACT EXTRACTION:

A combination of these surgeries is needed when surgery for intraocular pressure (IOP) lowering is appropriate and a vision affecting cataract is also present. Glaucoma patients who are undergoing cataract surgery do not always need combined surgery. In order to avoid problems of high postoperative IOP these procedures need to be considered for patients taking many medications and in those with relatively advanced glaucoma. The desired IOP level of after surgery, the severity of disease and the likely benefit in vision quality after cataract extraction will dictate the decision to perform a combined procedure.

Differentiation between a one site or a two site approach for both surgeries depends on the surgeons comfort. There is little evidence to choose from a limbal or a fornix based approach for surgery. In patients with cataract and stable glaucoma, if subsequent trabeculectomy is needed, a clear corneal approach can be use at the first sitting.

FULL-THICKNESS SURGERIES:

There are many procedures. Few of them are thermal sclerostomy (Scheie procedure) which was popular some time ago, sclerectomy, trephination and iridencleisis. These are only of historical interest now

GLAUCOMA DRAINAGE DEVICES (GDD):

Glaucoma drainage devices are used if it is anticipated that trabeculectomy is might not be successful owing to logistical or socioeconomic issues. Prevention of early postoperative hypotony largely depends on restriction of flow of aqueous humor from the eye. GDDs that lack check mechanism will need a ligature. An internal stent or some form of flow controlling mechanism can also be employed. Surface area of the plate of the GDD is directly related to the decrease in IOP[18].

Scarring around the plate is often the most important cause of failure of GDDs. Success with GDDs is not enhanced with antifibrotic agents. In a patient who has had a pars plana vitrectomy, pars plana positioning of the GDD can be done. It is also attempted in someone for whom the seton cannot be safely inserted into the AC.

NON PENETRATING GLAUCOMA DRAINAGE SURGERY (NPGDS):

This recent advancement gives an alternative surgical for lowering of IOP in glaucoma when compared to the conventional approach of trabeculectomy. Nd:YAG laser goniolysis can be a part of the surgery when employed postoperatively. External filtration with deep sclerectomy will increase the success rate of the procedure. Viscocanalostomy has not shown high IO P drop after surgery.

Deep sclerectomy provides a better IOP control than viscocanalostomy. There are ongoing studies in this regard.Success of subsequent trabeculectomy is affected by prio NPGDS.

CYCLODESTRUCTIVE PROCEDURES:

The procedure used in refractory glaucoma where trabeculectomy or GDDs could fail or induce surgical complication is one of the cyclodestructive procedures. Of the many such procedures available, cyclophotocoagulation using the laser diode (the G-probe laser) is most preferred.

G probe cyclophotocoagulation by the transscleral method is done when maximal medical treatment, trabeculectomy or drainage implant surgery cannot be done due to any reason. Transillumination of the eye to identify the ciliary location body may be useful before transscleral cyclophotocoagulation. This is specifically done in

morphologically abnormal eyes. Steroids and cycloplegic drugs are used to reduce the complications and irritation that may be present. Treatment effectiveness needs to be assessed after 1 month. By then, the option of repeating the procedure can be feasible. Minimal laser application which can be repeated is better than high dose treatment in a single sitting. This will help to reduce the complications of treatment.

TRABECULECTOMY WITH ANTI-METABOLITES:

MITOMYCIN C (MMC):

Streptomyces caespitosus is the organism from which this anti-neoplastic antibiotic is developed. A complete inhibiton of proliferation of fibroblast is seen on tissue culture when this agent has been used. Trabeculectomy can thus be made more effective with its use. It is seen to increase the success surgeries done for glaucoma. Previously, MMC was used in the dose of 0.5 mg in one ml. It was used on the sub-conjunctival tissues and left in place for 6 minutes.

However, recent studies show that MMC used for 2 minutes in the dose of 0.02% is as effective as using 0.5mg in one ml. Hypotonous maculopathy is the most feared complication associated with use of MMC.

5-FLUOROURACIL:

Blockade of DNA synthesis by this pyrimidine analogue which falls under the class of anti-metabolite is the mechanism employed to decrease proliferation of fibroblasts in cell culture. Increase in the bleb formation after surgery is seen by using sub-conjunctival injections of 5-FU. The most serious side effect is corneal toxicity[19]. Sustained release conjunctival implants are undergoing clinical trials. The use is in the dose 30 to 50 mg per ml during surgery. It is placed with a cellulose tipover the site for 5 minutes. Now, 5FU has been replaced by most experts with MMC.

Use of 5FU as an adjunct is not practiced now as evidence points that that it is not as effective. Trabeculectomy alone is more successful than combined procedures for IOP decrease. Results of previous trabeculectomy surgery are often sdversely affected by subsequent cataract surgery[20].

TRABECULECTOMY WITH COLLAGEN IMPLANTS:

The biodegradable collagen implant is being used as a newer modality for increasing the long term success of trabeculectomy. Cellular regeneration around poorly healed wounds with the use of bioengineered tissues is now used in many surgeries[21, 22]. Production of these implants is by the use of primary cells implanted into scaffolding made of synthetic polymer. The matrix is then cultured. The regenerative process employs either species specific cells which may be taken from tissues adjacent the

wound[23, 24]. Other cells developed invitro like the stem cells are also used. Formation of structures that are very similar to parent tissue can be seen after natural biodegradation of scaffold. Prevention of scarring after trabeculectomy by the implant is by a process of subconjunctival wound healing modulation and architectural streamlining. There is also a reorganization of the newly forming fibroblasts and adjacent extracellular substances.

The success of trabeculectomy is increased by use of a three dimensional collagen based glycosaminoglycan structure that is inherently porous. A space in between the conjunctiva and sclera is use to place the implant. This then acts like a spacer. It mainly helps in maintaining the patency of the subconjunctival area. Modulation of wound healing is the main mechanism. This is very different from the action of 5FU or MMC. Collagen implants do not affect proliferation of fibroblasts in a direct way. They direct the regenerating collagen to be deposited in a orderly pattern rather than randomly[25, 26].

The risk of postsurgical infection is not very prominent as the surface immunity of the conjunctival tissue is not altered. Infection rates are less than those with 5FU and MMC.

Current studies show that the biodegradable collagen implant is very safe and efficacious. Over-filtration, a problem associated with MMC and 5FU is not seen with these collagen implants. Thus in patients with a history of hypotonous maculopathy in

the fellow eye after MMC based trabeculectomy, it is an option. Patients who have blepharitis in whom antifibroblastic agents can cause eye infection are also suitable candidates[27, 28]. Combined surgery for cataract extraction and trabeculectomy with these collagen implants is very feasible for glaucoma patients on two drugs and significant lens changes.

To conclude, scar formation along the pathway of filtration leads to trabeculectomy failure over the course of time[29]. This occurs more often with patients who have undergone previous surgery for glaucoma. Mitomycin C and 5-fluorouracil are antifibrotic agents that are associated with some significant complications like cystic blebs, bleb leak, hypotonous maculopathy and endophthalmitis. As of today, studies show that the biodegradable collagen implant is a simple and effective option for the treatment of refractory glaucoma. It is seen to be safer than antifibrotic agents in the prevention of scar formation after trabeculectomy[30, 31].

In our study, we have used the collagen matrix available in the form of a 6 x 2 mm disc as shown in the picture.

COMPLICATIONS OF TRABECULECTOMY

- Buttonholing the conjunctiva
- Flat anterior chamber with hypotony
- Flat anterior chamber in normotensive and hypertensive eyes

- Malignant glaucoma
- Suprachoroidal hemorrhage
- Intraoperative flat anterior chamber
- Hyphema
- Intraocular infection
- Sympathetic ophthalmia
- Filtration failure
- Dellen
- Hypotonous maculopathy

BLEB RELATED COMPLICATIONS

- Thin-walled blebs
- Bleb migration onto cornea
- Diffuse blebs
- Overfunctioning blebs

DEFINITION OF SURGICAL SUCCESS:

The outcome of glaucoma surgery can be graded based on various parameters at the end of followup. In this regard, complete success and qualified success are described.

COMPLETE SUCCESS: When the intraocular pressure is maintained less than 21 mm of Hg throughout the study period without the use of additive therapy and when there is no progression of field defects by automated perimetry nor loss of RNFL by OCT, complete success is said to be attained.

QUALIFIED SUCCESS: If the intraocular pressure is maintained at less than 21 mm of Hg with the use of additional therapy, the surgery qualifies as success on limited terms.

UNSUCCESSFUL: When the IOP is not consistently less than 21 mm of Hg and progression of field defects and RNFL is not halted despite use of additional therapy, then the filtering surgery is termed unsuccessful.

MOOREFIELDS BLEB GRADING:

A photograph based grading system for the bleb morphology has been introduced by the Moorefields Eye Hospital. A photograph of the patient's eye is taken with the patient looking down exposing a maximum part of the superior conjunctiva and the bleb. This photograph is then compared to a standard set of photographs prepared by the Moorefields Eye Hospital and the patients bleb is graded based on three criteria: the bleb area, bleb height and bleb vascularity.

1. Area of the bleb

    - Central area: Grade 1 to 5

    -Maximal area: Grade 1 to 5

2. Height of the bleb

- Highest point on the bleb: Grade 1 to 4

3. Bleb vascularity

- Central area: Grade 1 to 5
- Maximal area: Grade 1 to 5
- Conjunctiva away from the bleb: Grade 1 to 5

This system helps in evaluating the functional status of the surgical blebs. It is also a document for future reference and progression monitoring

Figure 1. Structures in the angle of the anterior chamber and the pathway of aqueous outflow.

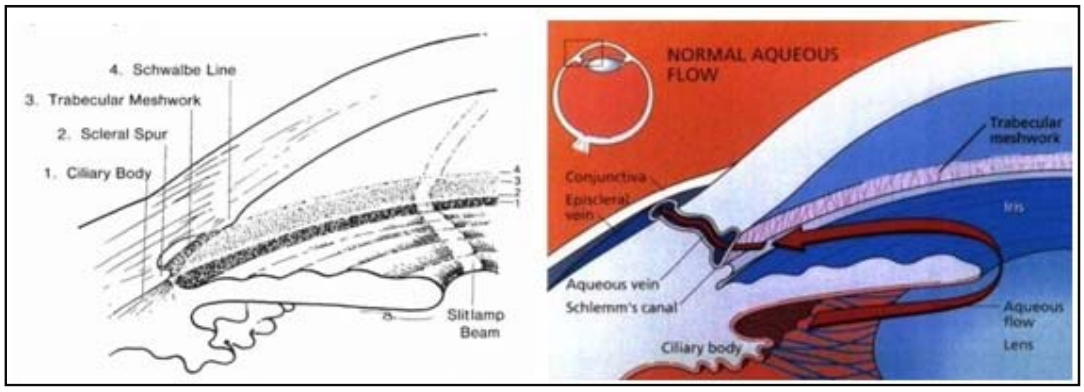


Figure 2. An ideal bled seen after trabeculectomy that is avascular, diffuse and microcystic in appearance.

Figure 3. UBM showing a well formed functional bleb.

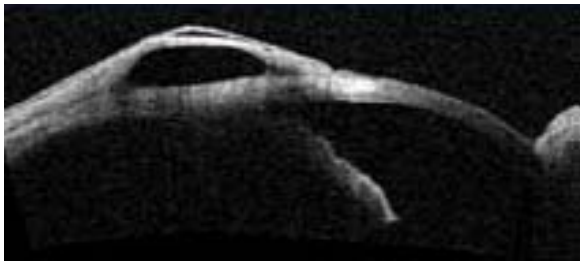


Figure 4. The collagen implant of 6 mm diameter and 2 mm height used in the study.

Figure 5. Implant seen between the conjunctiva and the sclera

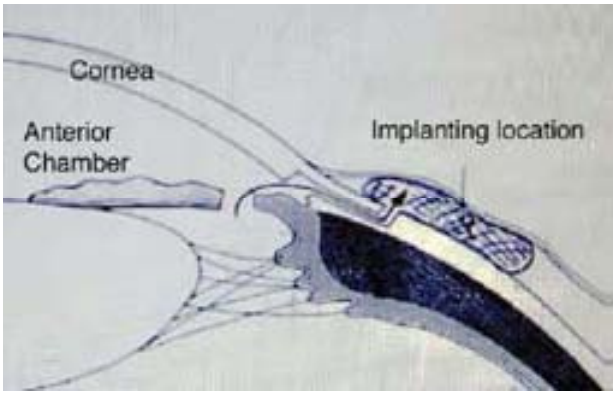


Figure 6. A histologic section from an experimental eye shows that the implant is covered by conjunctival epithelium 1 month post-operatively

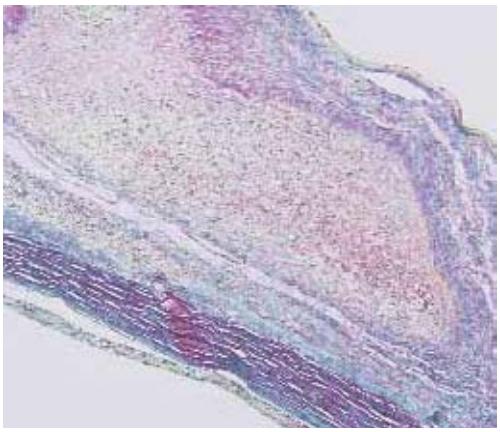
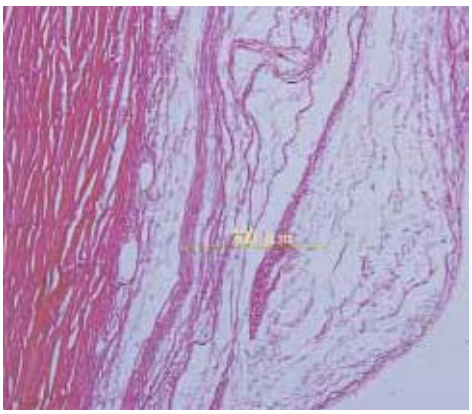


Figure 7. By the 6th postoperative month, the implant's polymer matrix has degraded, leaving behind a connective tissue framework that forms the bleb.



OBJECTIVES OF THE STUDY

An analytical study of the surgical outcomes of trabeculectomy with and without ologen implant was done. The aims of the study were

- To evaluate the success rate of trabeculectomy with OloGen implant and to compare the outcomes with plain trabeculectomy.
- To look for any local effects due to the implant & bleb related complications

METHODOLOGY (MATERIALS & METHODS)

Subject Selection:

Patients presenting to the Glaucoma services of RIO-GOH over a period of 2 years (July 2010 to June 2012).

Screening & Procedure:

39 Glaucomatous eyes of 35 patients meeting the eligibility criteria were enrolled in this prospective study. After obtaining the informed consent from the patient detailed history taking followed by thorough glaucoma evaluation- Visual acuity recording by the Snellen's chart, IOP by both non-contact tonometry and by Goldmann applanation tonometry (after correction for the central corneal thickness by pachymetry), slit lamp examination & gonioscopy by Goldmann single mirror, fundus

examination by 78D lens, fields by Octopus automated perimetry (AP) & ONH topography with retinal nerve fiber thickness (RNFL thickness) by Optical Coherence Tomography (OCT) was done.

The patients are randomly allotted into 2 groups. Those in group A underwent trabeculectomy alone while those in group B underwent trabeculectomy with an Ologen implant. 20 eyes were allotted to group A and 19 eyes were allotted to group B. In the trabeculectomy group, there were 9 eyes with POAG, 9 eyes with PACG and 2 eyes with developmental glaucoma. Similarly the trabeculectomy with OloGen group had 8 eyes with POAG, 8 eyes with PACG and 3 eyes with developmental glaucoma.

Trabeculectomy was done by fornix based conjunctival peritomy. Thereafter, a 3x3 mm triangular limbus based scleral incision was fashioned in both groups. A triangular partial thickness scleral flap is raised and 2x2 mm of the deep sclera was removed using Kelly's punch. A peripheral iridectomy (PI) was performed. The scleral flap was replaced and secured in place by two interrupted 10-0 polyamide sutures and the conjunctiva sutured over the wound with 8-0 vicryl sutures. In those patients in group B alone, the Ologen implant was placed over the scleral flap before suturing the conjunctiva. The implant measuring 6 mm in diameter and 2 mm in thickness was removed from its sterile packing and after ensuring minimal exposure

to the ambient air, was placed above the triangular flap. Suturing of the scleral flap was done with minimal resultant tension on the sutures. However, the conjunctiva was secured to be water tight.

Inclusion Criteria:

- Eyes with advanced glaucomatous damage due to open or angle closure glaucoma.
- Patients showing progression of field defects by perimetry inspite of topical medications.

Exclusion Criteria:

- All cases of secondary open or angle closure glaucoma
- Diagnosed cases of macular dystrophy or degeneration.
- Patients with retinal vascular occlusion (Retinal artery or vein)
- Patients with diabetic or hypertensive retinopathy.
- Patients with early stages of primary open angle glaucoma who could be managed with topical medications.
- Patients with early stages of primary angle closure glaucoma for whom laser iridotomy would be appropriate

Follow up Procedures / Visits:

- Patients were examined at discharge, 1st week, 1st month, 3rd month, 6th month, 1st year and 2nd year.
- Visual acuity, IOP by both non-contact tonometry and by Goldmann applanation, fundus examination by 78D lens are done at every visit.
- Angle study with Ziess 4 mirror & visual fields by Octopus perimetry are done every 6 months.
- ONH topography with RNFL thickness by OCT is to be repeated after a year.
- Ultrasound Biomicroscopy (UBM) was done in selected patients.

Assessments of Parameters:

Periodic examination of visual acuity, IOP, evaluation of disc by 78 D, anterior chamber angles by gonioscopy, visual fields by AP, assessment of RNFL for documentation of progression.

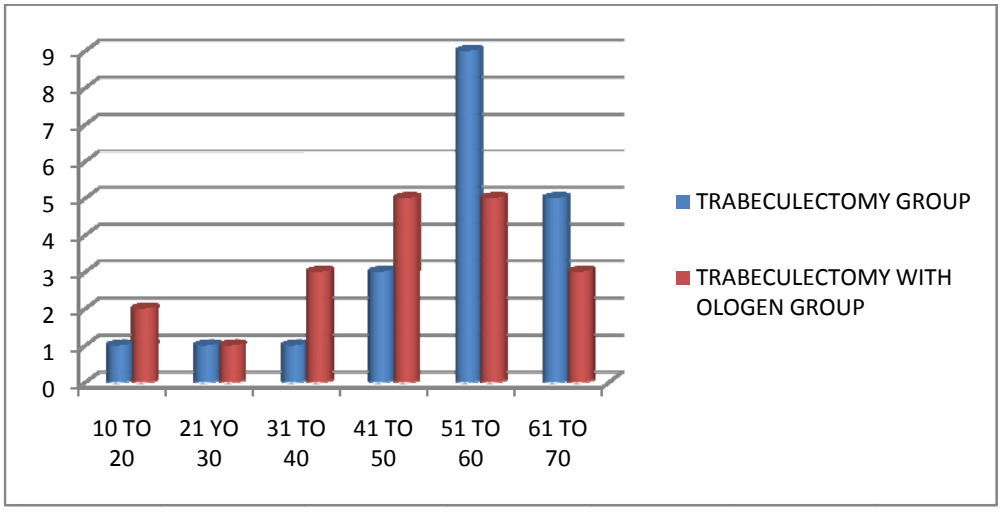
OBSERVATION AND RESULTS

AGE DISTRIBUTION

Table 1. Age distribution of the 39 eyes enrolled

S. NO	AGE	TRABECULECTOMY GROUP (NO. OF EYES)	TRABECULECTOMY WITH OLOGEN IMPLANT GROUP (NO. OF EYES)
1.	10 – 20	1	2
2.	21 – 30	1	1
3.	31 – 40	1	3
4.	41 – 50	3	5
5.	51 – 60	9	5
6.	61 – 70	5	3
TOTAL		20	19

Figure 8. Age distrubution of the eyes enrolled in the two groups



Most patients in our study were in the 51 to 60 year age group (46% of patients in the trabeculectomy group and 26% of patients in the trabeculectomy with collagen implant group). This pattern conforms to the fact that glaucoma is more often an affection of older age groups as seen from other studies[15, 16, 17].

SEX DISTRIBUTION

Table 2. Distribution between males and females

S. NO	SEX	TRABECULECTOMY GROUP (NO. OF EYES)	TRABECULECTOMY WITH OLOGEN IMPLANT GROUP (NO. OF EYES)
1.	MALE	10	11
2.	FEMALE	10	8

Figure 9. Distribution of eyes between the sexes in the trabeculectomy group

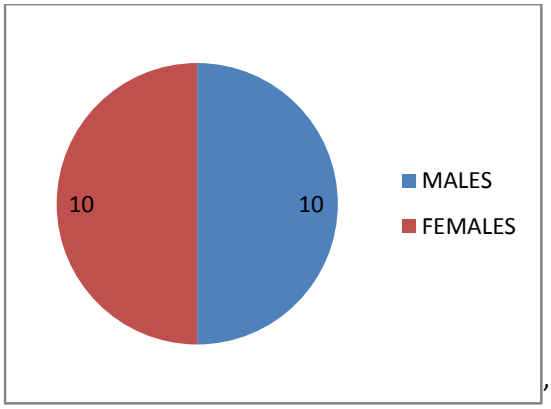
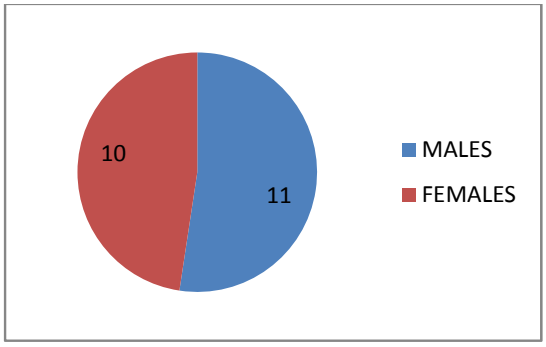


Figure 10. Distribution of eyes between the sexes in the trabeculectomy with OloGen group



As is seen from the above table and figures, males and females were equally distributed in both groups under study. Statistical analysis for difference between the

groups done using the Chi square test showed a p value of 0.621 which is not significant.

DISEASE PATTERNS IN THE TWO GROUPS

Table 3. Diagnosis of the eyes enrolled for the study

S. NO	SEX	TRABECULECTOMY GROUP (NO. OF EYES)	TRABECULECTOMY WITH OLOGEN IMPLANT GROUP (NO. OF EYES)
1.	POAG	9	8
2.	PACG	9	8
3.	Developmental Glaucoma	2	3
TOTAL		20	19

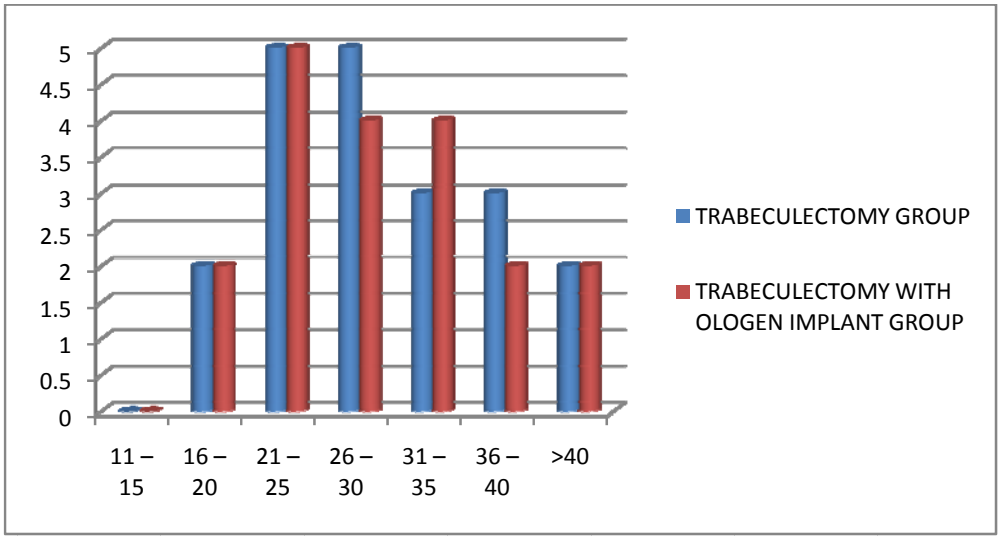
In the trabeculectomy group, there were 9 eyes with POAG, 9 eyes with PACG and 2 eyes with developmental glaucoma. Similarly the trabeculectomy with OloGen group had 8 eyes with POAG, 8 eyes with PACG and 3 eyes with developmental glaucoma.

INTRA-OCULAR PRESSURE AT PRESENTATION

Table 4. IOP distribution in the eyes enrolled for the study

S. NO	IOP BY GOLDMANN APPLANATION	TRABECULECTOMY GROUP (NO. OF EYES)	TRABECULECTOMY WITH OLOGEN IMPLANT GROUP (NO. OF EYES)
1.	11 – 15	-	-
2.	16 – 20	2	2
3.	21 – 25	5	5
4.	26 – 30	5	4
5.	31 – 35	3	4
6.	36 – 40	3	2
7.	>40	2	2

Figure 11. IOP distribution for the eyes enrolled



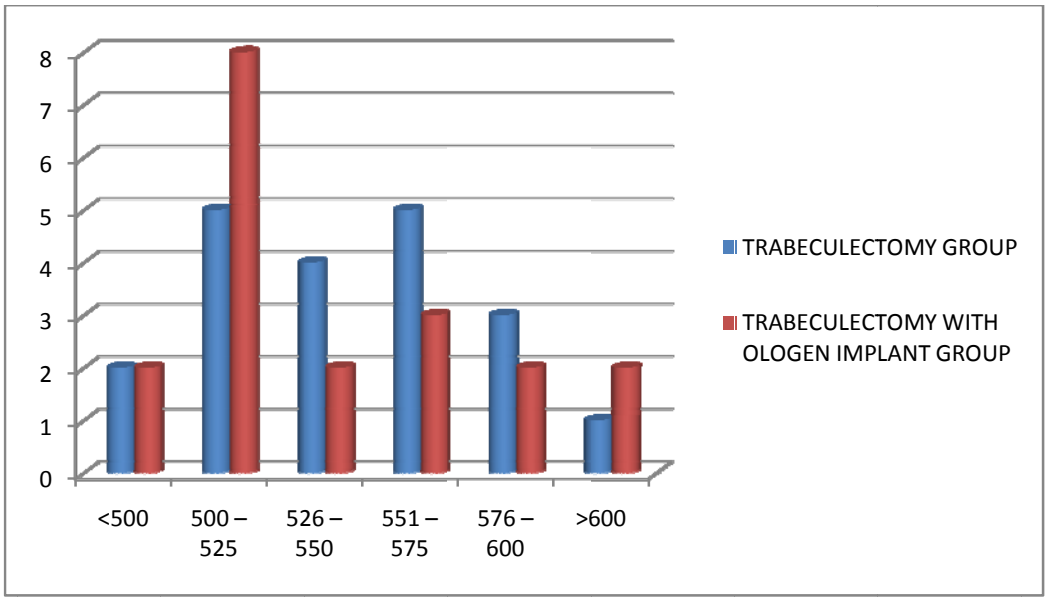
In both groups, most patients had an IOP in the range of 21 to 25 mm of Hg (25% in the trabeculectomy group and 26% in the trabeculectomy with OloGen group). Few patients in the lower IOP range of 16 to 20 mm of Hg also required surgery in view of their advanced glaucomatous optic nerve damage and field changes. Findings were comparable to the study by Heijl et al[8].

CENTRAL CORNEAL THICKNESS

Table 5. CCT values for the eyes enrolled

S. NO	CCT	TRABECULECTOMY GROUP (NO. OF EYES)	TRABECULECTOMY WITH OLOGEN IMPLANT GROUP (NO. OF EYES)
1.	<500	2	2
2.	500 – 525	5	8
3.	526 – 550	4	2
4.	551 – 575	5	3
5.	576 – 600	3	2
6.	>600	1	2

Figure 12. CCT values for eyes enrolled



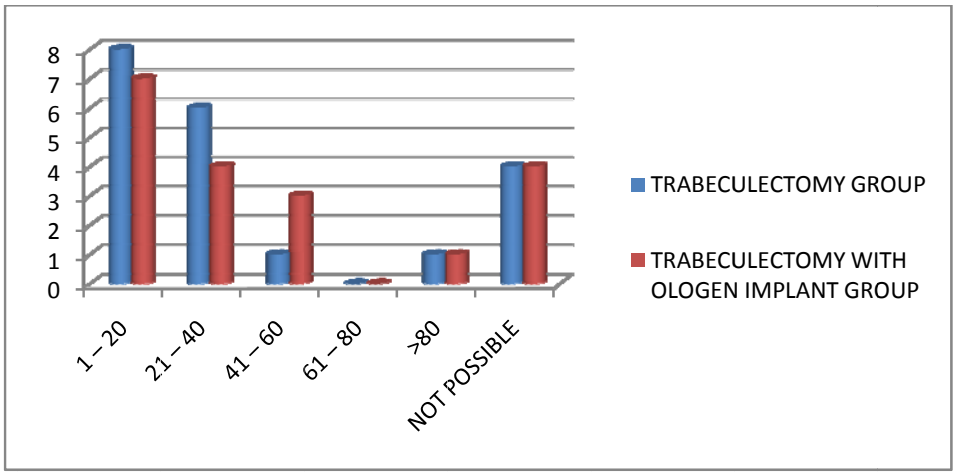
In the trabeculectomy group, 85% of the patients (17 patients) had their CCT between 501 and 600 microns. In the group with the OloGen implant, 79% of the patients (15 patients) had a CCT in the same range. CCT values in the extremes (less than 500 microns and more than 600 microns) were seen in 3 patients and 4 patients respectively.

AUTOMATED PERIMETRY (LOSS VARIANCE) AT PRESENTATION

Table 6. Loss variance measured by the Octopus AP

S. NO	AUTOMATED PERIMETRY (LV)	TRABECULECTOMY GROUP (NO. OF EYES)	TRABECULECTOMY WITH OLOGEN IMPLANT GROUP (NO. OF EYES)
1.	1 – 20	8	7
2.	21 – 40	6	4
3.	41 – 60	1	3
4.	61 – 80	-	-
5.	>80	1	1
6.	NOT POSSIBLE	4	4

Figure 13. Loss variance of the eyes enrolled



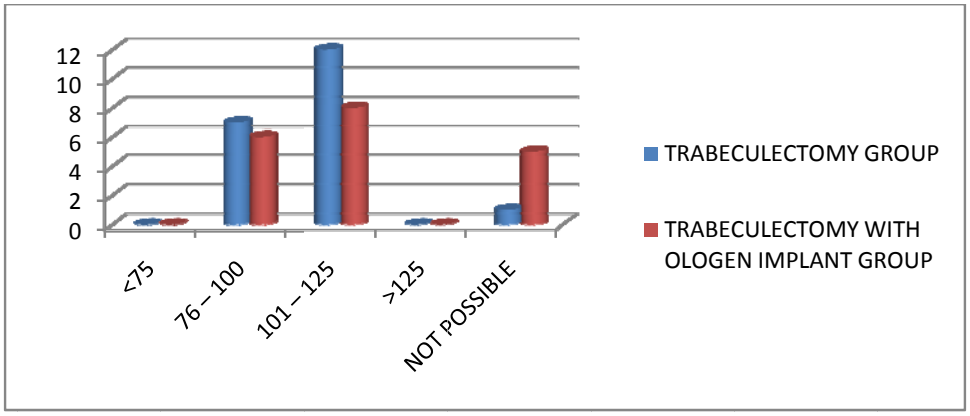
Loss variance in Octopus AP was taken as a marker of focal defects attributable to glaucoma. Since 4 patients in each group could not perform the automated perimetry, they were excluded from the analysis.

RETINAL NERVE FIBER LAYER (RNFL) THICKNESS BY OCT AT PRESENTATION

Table 7. RNFL thickness by the OCT

S. NO	RNFL THICKNESS	TRABECULECTOMY GROUP (NO. OF EYES)	TRABECULECTOMY WITH OLOGEN IMPLANT GROUP (NO. OF EYES)
1.	<75	-	-
2.	76 – 100	7	6
3.	101 – 125	12	8
4.	>125	-	-
5.	NOT POSSIBLE	1	5

Figure 14. RNFL thickness distribution



In our study, the RNFL thickness measured by OCT showed that most patients (60% in the trabeculectomy group and 42% in the OloGen implant group) taken up for surgery in both groups had an average RNFL thickness in the range of 101 to 125 microns. Most patients with an RNFL thickness in the range of 76 to 100 microns were diagnosed to have POAG while those with an RNFL thickness of 101 to 125 microns were PACG patients who required surgery to establish an outflow path. None of them had a healthy RNFL thickness average of more than 125 microns.

OPTIC DISC:CUP RATIO AT PRESENTATION

Table 8. ONH cup: disc ratio

S. NO	C:D RATIO	TRABECULECTOMY GROUP (NO. OF EYES)	TRABECULECTOMY WITH OLOGEN IMPLANT GROUP (NO. OF EYES)
1.	<0.4	-	-
2.	0.4	1	1
3.	0.5	2	2
4.	0.6	1	1
5.	0.7	3	3
6.	0.8	7	6
7.	0.9	6	6

As seen from table 8, 30% of patients in the trabeculectomy group and 32% of patients in the OloGen group had an advanced cupping of 0.9 at the time of surgery.

EFFECT OF TRABECULECTOMY ON OCULAR PARAMETERS OVER A 2 YEAR FOLLOW-UP

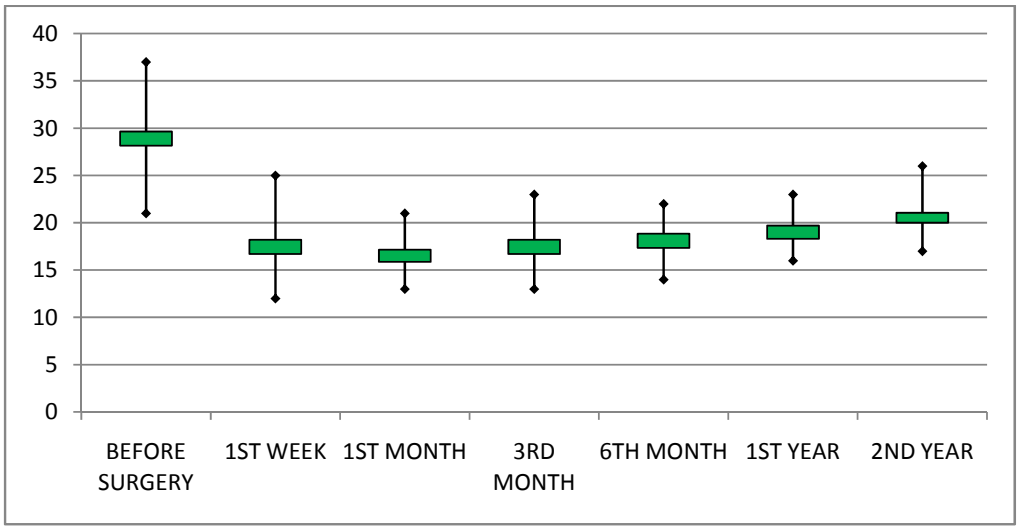
Table 9. Ocular parameters after trabeculectomy surgery over a two year period

S.NO	PARA. STUDIED	PRE SURG.	POST SURGERY						P VALUE
			1ST WEEK	1ST MONTH	3RD MONTH	6TH MONTH	1ST YEAR	2ND YEAR	
1.	IOP BY GAT	29.65 ± 8.16	18.20 ± 6.35	17.16 ± 3.53	18.20 ± 4.12	18.85 ± 3.65	19.70 ± 3.95	21.05 ± 4.48	<0.01**
2.	CUP: DISC	0.77 ± 0.14	0.76 ± 0.15	0.76 ± 0.15	0.76 ± 0.15	0.76 ± 0.15	0.76 ± 0.15	0.77 ± 0.13	0.016*
3.	AP LV	24.05 ± 19.64	-	-	-	19.31 ± 16.64	16.60 ± 13.50	18.53 ± 11.04	0.248
4.	OCT RNFL	103.37 ± 17.79	-	-	-	102.89 ± 18.12	101.53 ± 17.07	101.96 ± 17.30	0.050*

** Significant at 1%

* Significant at 5%

Figure 15. IOP levels monitored for a period of two years after trabeculectomy surgery



Our study showed a significant drop in the IOP over a two year period in eyes that underwent trabeculectomy. Data was analysed using the Friedman non-parametric test and the p value was less than 0.001. A significant difference was also noted in the c:d ratio after two years with the p value being 0.016. There was no significant difference in the loss variance. The RNFL thickness, however, showed a significant drop (p value of 0.05). The findings were comparable to the study by Papaconstantinou et al[24] which was published in 2010.

EFFECT OF TRABECULECTOMY WITH OLOGEN IMPLANT ON OCULAR PARAMETERS OVER A 2 YEAR FOLLOW-UP

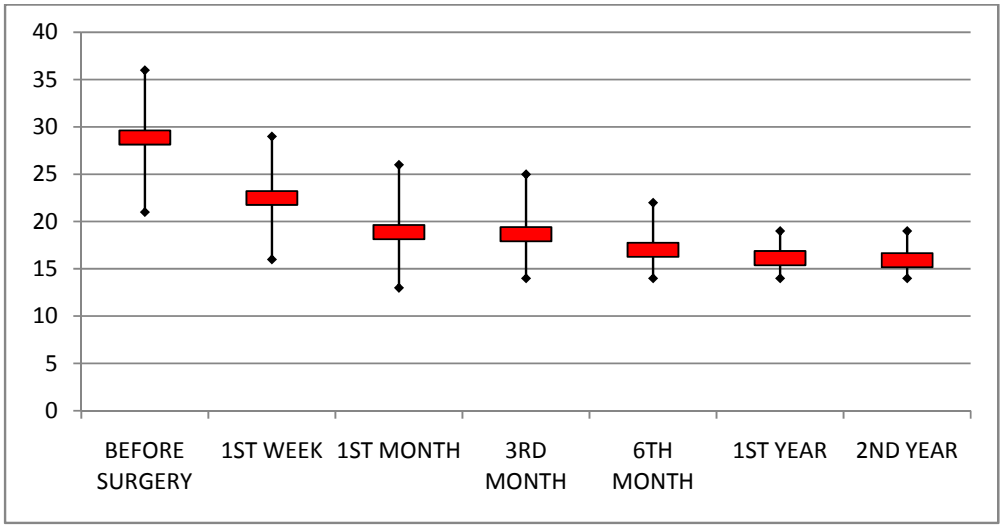
Table 10. Ocular parameters after trabeculectomy surgery with OloGen implant over a two year period

S.NO	PARA STUDIED	PRE SURG.	POST SURGERY						P VALUE
			1ST WEEK	1ST MONTH	3RD MONTH	6TH MONTH	1ST YEAR	2ND YEAR	
1.	IOP BY GAT	29.63 ± 7.73	23.21 ± 6.51	19.63 ± 7.41	19.41 ± 6.57	17.76 ± 4.35	16.88 ± 2.99	16.67 ± 2.73	<0.001**
2.	CUP: DISC	0.75 ± 0.15	0.75 ± 0.15	0.75 ± 0.15	0.75 ± 0.16	0.77 ± 0.15	0.77 ± 0.15	0.78 ± 0.13	0.062
3.	AP LV	26.97 ± 20.90	-	-	-	19.08 ± 14.12	20.00 ± 13.10	16.18 ± 11.85	0.225
4.	OCT RNFL	103.35 ± 19.96	-	-	-	103.64 ± 19.74	103.07 ± 18.39	104.14 ± 18.34	0.549

** Significant at 1%

* Significant at 5%

Figure 16. IOP levels monitored for a period of two years after trabeculectomy surgery with OloGen implant



A two year follow-up of patients who underwent trabeculectomy with the OloGen implant showed a significant drop in the IOP. Statistical analysis performed with the Freidman test showed a p value of less than 0.001. Subsequent analysis did not show any statistically significant difference in terms of change in the c:d ratio, loss variance or RNFL thickness.

COMPARISONS OF OUTCOME OF TRABECULECTOMY AND TRABECULECTOMY WITH OLOGEN OVER A FOLLOW-UP OF 2 YEARS

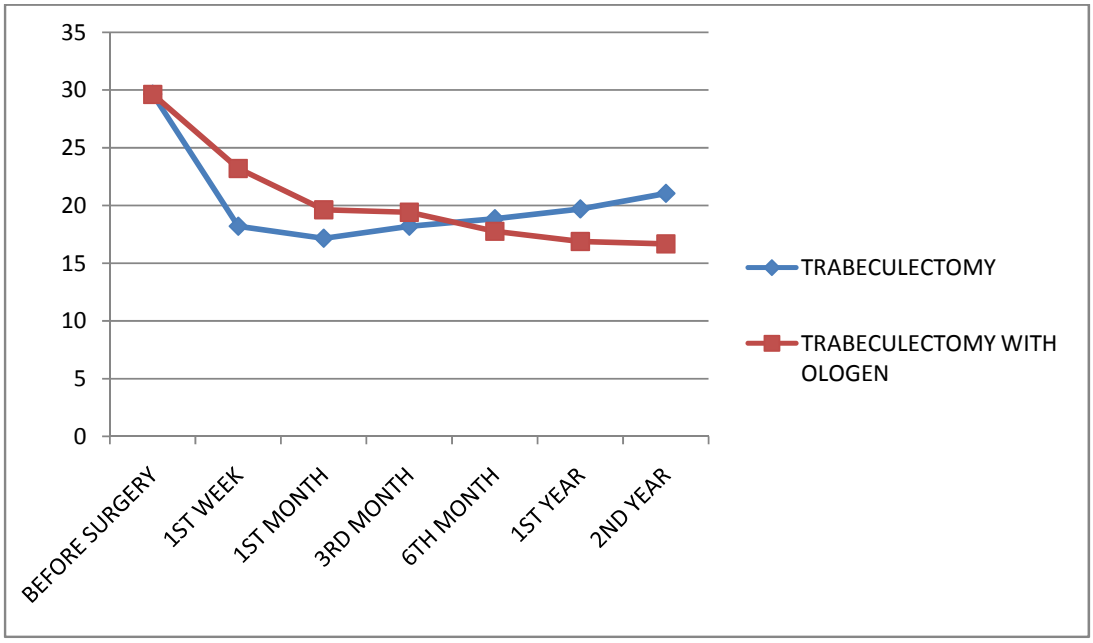
a. Measurement of intra-ocular pressure by the Goldman applanation tonometer

Table 11. Comparitive IOP levels during follow-up in the two groups

S. NO		IOP BY GAT						
		BEFORE SURGERY	AFTER SURGERY					
			1ST WEEK	1ST MONTH	3RD MONTH	6TH MONTH	1ST YEAR	2ND YEAR
1.	TRABECULECTOMY GROUP	29.65 ± 8.16	18.20 ± 6.35	17.16 ± 3.53	18.20 ± 4.12	18.85 ± 3.65	19.70 ± 3.95	21.05 ± 4.48
2.	TRABECULECTOMY WITH OLOGEN GROUP	29.63 ± 7.73	23.21 ± 6.51	19.63 ± 7.41	19.41 ± 6.57	17.76 ± 4.35	16.88 ± 2.99	16.67 ± 2.73
3.	P VALUE	0.994	0.020*	0.187	0.489	0.415	0.019*	0.001**

** Significant at 1%
* Significant at 5%

Figure 17. Comparitive IOP levels during follow-up in the two groups



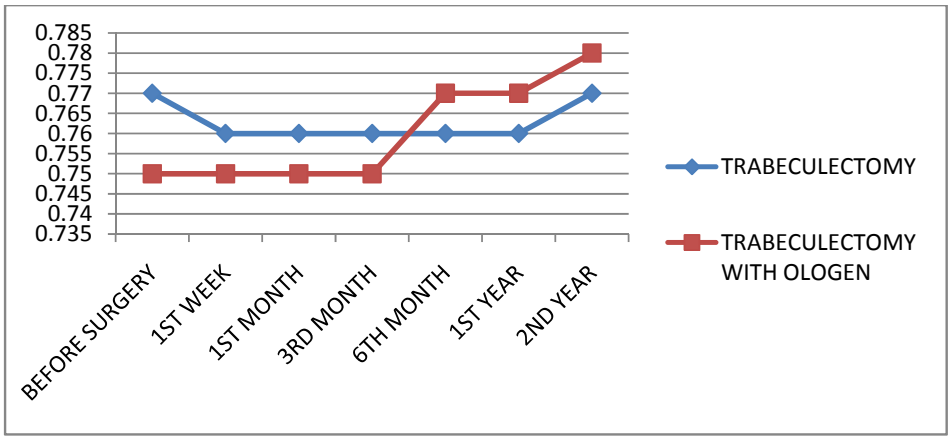
The intra-ocular pressure was measured in all patients during follow-up. They were grouped according to the surgery performed and the IOP values between the groups at every follow-up were compared and statistically analysed using the Independent Sample t test. While there was no significant difference between the two groups before surgery, IOP values were significantly more in the OloGen group at the 1st week of follow-up. However, eyes in the OloGen group had significantly lesser IOP levels at the 1st and 2nd year of follow-up. The findings were comparable to the study by Papaconstantinou et al[24] which was published in 2010. Similar results were obtained in India by Tanuj et al[31].

b. Measurement of the optic cup : disc ratio

Table 12. Comparision of c:d ratio during follow-up in the two groups

S. NO		CUP : DISC RATIO						
		BEFORE SURGERY	AFTER SURGERY					
			1ST WEEK	1ST MONTH	3RD MONTH	6TH MONTH	1ST YEAR	2ND YEAR
1.	TRABECULECTOMY GROUP	0.77 ± 0.14	0.76 ± 0.15	0.76 ± 0.15	0.76 ± 0.15	0.76 ± 0.15	0.76 ± 0.15	0.77 ± 0.13
2.	TRABECULECTOMY WITH OLOGEN GROUP	0.75 ± 0.15	0.75 ± 0.15	0.75 ± 0.15	0.75 ± 0.16	0.77 ± 0.15	0.77 ± 0.15	0.78 ± 0.13
3.	P VALUE	0.744	0.962	0.962	0.953	0.911	0.911	0.868

Figure 18. Comparision of c:d ratio during follow-up in the two groups



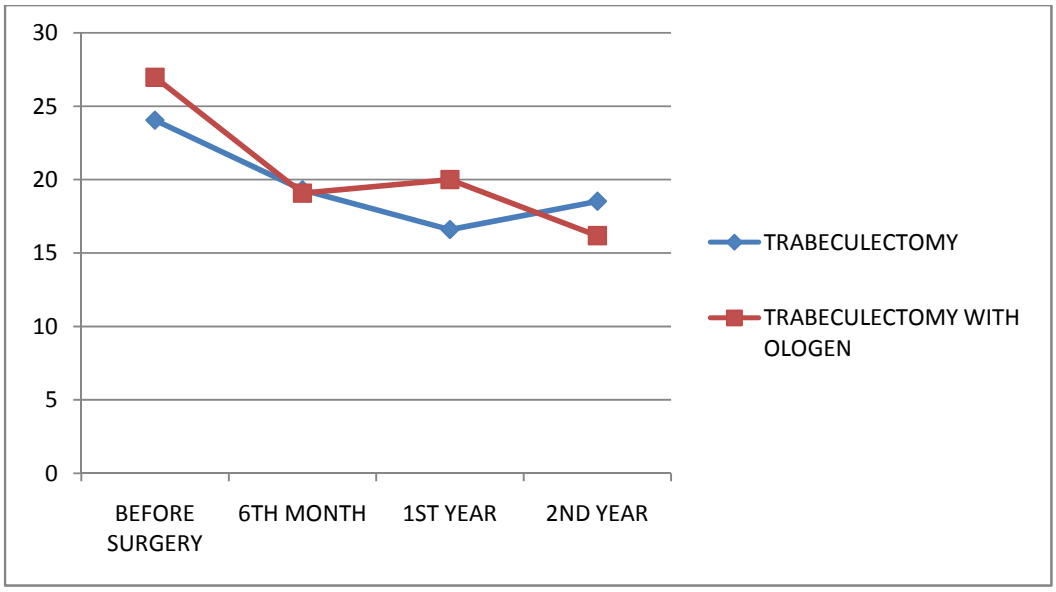
In our study, comparison of the C:D ratio did not show any significant difference before surgery nor at any stage of follow-up.

c. Measurement of the loss variance seen on the octopus automated perimetry

Table 13. Comparision of Loss Variance during follow-up in the two groups

S. NO		LOSS VARIANCE IN OCTOPUS AP			
		BEFORE SURGERY	AFTER SURGERY		
			6^{TH} MONTH	1^{ST} YEAR	2^{ND} YEAR
1.	TRABECULECTOMY GROUP	24.05 ± 19.64	19.31 ± 16.64	16.60 ± 13.50	18.53 ± 11.04
2.	TRABECULECTOMY WITH OLOGEN GROUP	26.97 ± 20.90	19.08 ± 14.12	20.00 ± 13.10	16.18 ± 11.85
3.	P VALUE	0.690	0.968	0.483	0.573

Figure 19. Comparision of Loss Variance during follow-up in the two groups



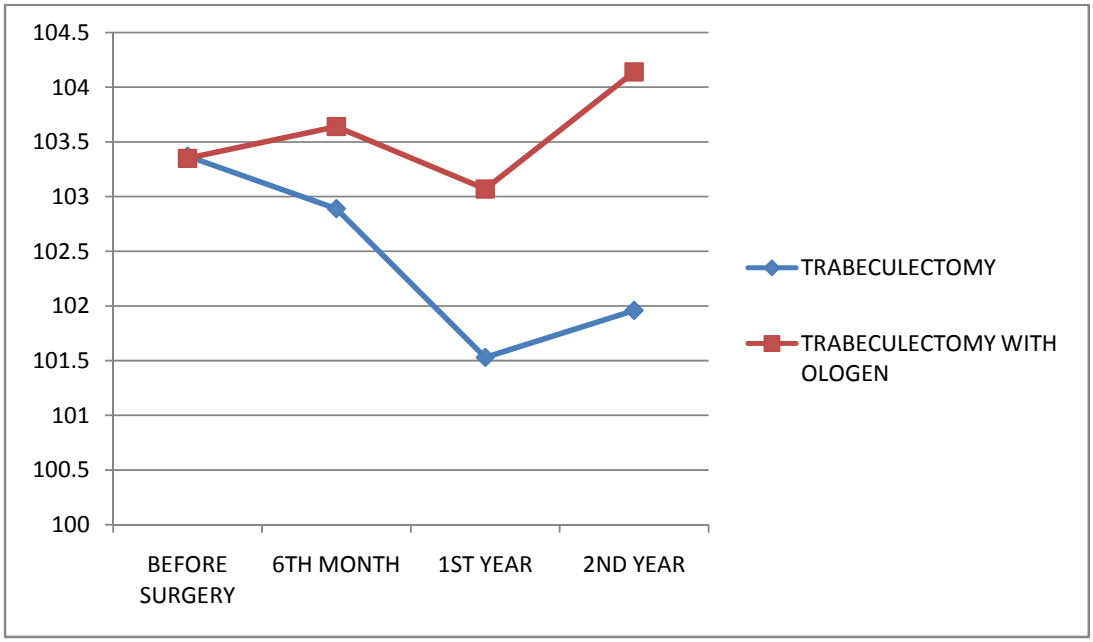
Analysis of the Loss variance obtained by octopus automated perimetry in all eyes showed a gradual decline in LV over a two year period. Nevertheless, no significant difference could be demonstrated between the two groups at any stage of follow-up by statistical analysis.

d. Measurement of the retinal nerve fiber layer (RNFL) thickness by OCT

Table 14. Comparision of RNFL thickness during follow-up in the two groups

S. NO		RNFL THICKNESS IN OCT			
		BEFORE SURGERY	AFTER SURGERY		
			6^{TH} MONTH	1^{ST} YEAR	2^{ND} YEAR
1.	TRABECULECTOMY GROUP	103.37 ± 17.79	102.89 ± 18.12	101.53 ± 17.07	101.96 ± 17.30
2.	TRABECULECTOMY WITH OLOGEN GROUP	103.35 ± 19.96	103.64 ± 19.74	103.07 ± 18.39	104.14 ± 18.34
3.	P VALUE	0.999	0.911	0.805	0.728

Figure 20. Comparision of RNFL thickness during follow-up in the two groups



The mean RNFL average at the end of a two year period was more in the OloGen group. Statistical analysis using the independent sample t test did not show any difference between the two groups.

EFFECT OF SURGERY ON VISUAL ACUITY AFTER TWO YEARS

Table 15. Status of the visual acuity over a follow-up of two years

	TRABECULECTOMY GROUP (NUMBER OF EYES)	TRABECULECTOMY WITH OLOGEN GROUP (NUMBER OF EYES)
IMPROVED	5	7
DETERIORATED	8	5
NO CHANGE	7	5

Visual acuity was checked at the end of two years and compared with the pre-operative vision. Statistical analysis using the Chi square test to compare the outcomes in both groups showed a p value of 0.83 which is not significant.

MOOREFIELDS BLEB GRADING:

Table 16. Grading of the blebs using the Standard Moorefields Bleb Grading Photographs

BLEB CHARACTERISTICS		TRABECULECTOMY GROUP (NUMBER OF EYES)					TRABECULECTOMY WITH OLOGEN GROUP (NUMBER OF EYES)				
		GRADE					GRADE				
		I	II	III	IV	V	I	II	III	IV	V
AREA OF THE BLEB	1a Central area	0	14	5	1	0	0	15	2	0	0
	1b Maximal area	0	15	5	0	0	0	3	10	4	0
HEIGHT OF THE BLEB	Highest point	10	5	4	1	-	2	11	4	0	-
BLEB VASCULARITY (GRADE 1 TO 5)	3a central area	2	16	2	0	0	1	13	2	1	0
	3b maximal area	1	18	1	0	0	1	9	5	2	0
	3c conjunctiva not forming the bleb	0	16	4	0	0	0	15	2	0	0

Grading of the bleb in each eye was done using the Moorefields bleb grading system (MBGS). From the table 16, it is seen that patients with Ologen implants had larger and more diffuse blebs. Patients undergoing trabeculectomy alone had blebs which were similar in area but flatter compared to the OloGen group. Blebs seen in this study were similar to the study group of Tanuj et al[31] and were large and diffuse.

SUCCESS RATE OF TRABECULECTOMY WITH AND WITHOUT THE OLOGEN IMPLANT:

Table 17. Outcome parameters for both groups after a one year follow-up

S. NO	OUTCOME OF SURGERY	TRABECULECTOMY GROUP (NUMBER OF EYES)	TRABECULECTOMY WITH OLOGEN GROUP (NUMBER OF EYES)
1.	COMPLETE SUCCESS	12	13
2.	QUALIFIED SUCCESS	4	2
3.	NEITHER	4	2

Table 18. Outcome parameters for both groups after a two year period

S. NO	OUTCOME OF SURGERY	TRABECULECTOMY GROUP (NUMBER OF EYES)	TRABECULECTOMY WITH OLOGEN GROUP (NUMBER OF EYES)
1.	COMPLETE SUCCESS	9	11
2.	QUALIFIED SUCCESS	5	3
3.	NEITHER	6	3

Applying the aforementioned criteria, after one year of follow-up, surgery was a complete success in 76% of the patients in the trabeculectomy with the OloGen implant group and 60 % in the trabeculectomy group. At the end of two years of follow-up, the rate of complete success dropped to 65% in the trabeculectomy with the OloGen implant while it was 45% in the trabeculectomy group. The result of surgery could neither be termed a complete success nor qualified success in 17% of the patients in the OloGen group and 30% of patients in the trabeculectomy group. Success rates were obtained with other studies are very similar to our study[24,27]. One study also shows a complete success in almost all with OloGen implants who had additional MMC[31].

INCIDENCE OF COMPLICATIONS WITH OLOGEN IMPLANT

Table 19. Complications encountered with the use of the OloGen implant

S. NO	COMPLICATIONS	NUMBER OF EYES	PERCENTAGE
1.	ALLERGIC REACTION	4	23.6%
2.	OVERHANGING BLEB	2	11.8%
3.	ENCYSTED BLEB	3	17.6%
4.	AVASCULAR BLEBS	1	5.9%
5.	BLEB LEAK	0	-
6.	BLEBITIS	0	-

Most common side effect encountered in 23.6% of patients having the OloGen implant was an allergic reaction to the implant which presented with localized congestion and irritation over the bleb area. All these patients were uniformly treated with Azelastine eye drops four times a day. 3 patients obtained relief within a week and one patient needed usage of the drops for a month. Large overhanging blebs were seen in 2 patients while 3 patients had a small encysted bleb. In the study published by Tanuj et al[31], hypotony and bleb leaks were also noted. However, we did not encounter any of these complications.

Figure 21. Immediate post-op picture showing the collagen implant in situ. 8-0 vicryl sutures used for conjunctival closure are also seen.

Figure 22. Allergic reaction to the implant with conjunctival congestion.

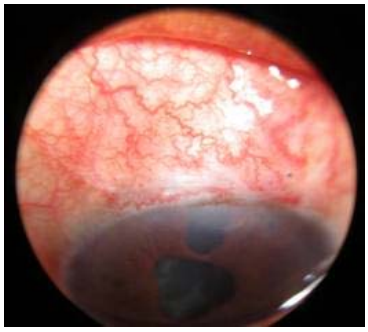


Figure 23. Well formed bleb after degradation of the collagen implant 8 months postoperatively.

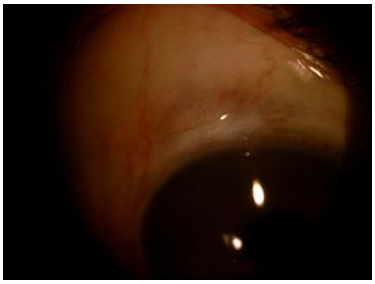


Figure 24. Larger diffuse bleb seen after implant integration at 1 year after surgery

Figure 25. Localised encysted bleb.

Figure 26. Grade 4 conjunctival vascularity by Moorefields Bleb grading.

Figure 27. Encysted avascular bleb.

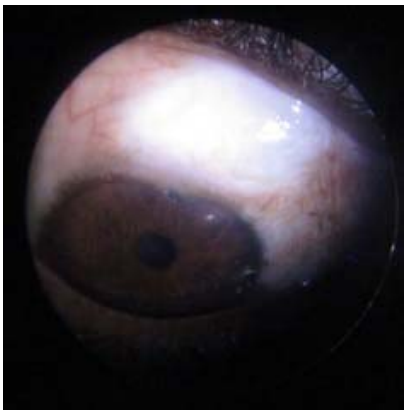


Figure 28. Flat diffuse bleb after plain trabeculectomy. The triangular scleral flap is seen.

Figure 29. UBM showing a partially degraded implant with a sub-conjunctival aqueous lake.

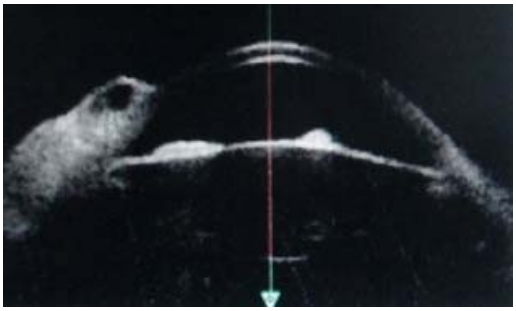
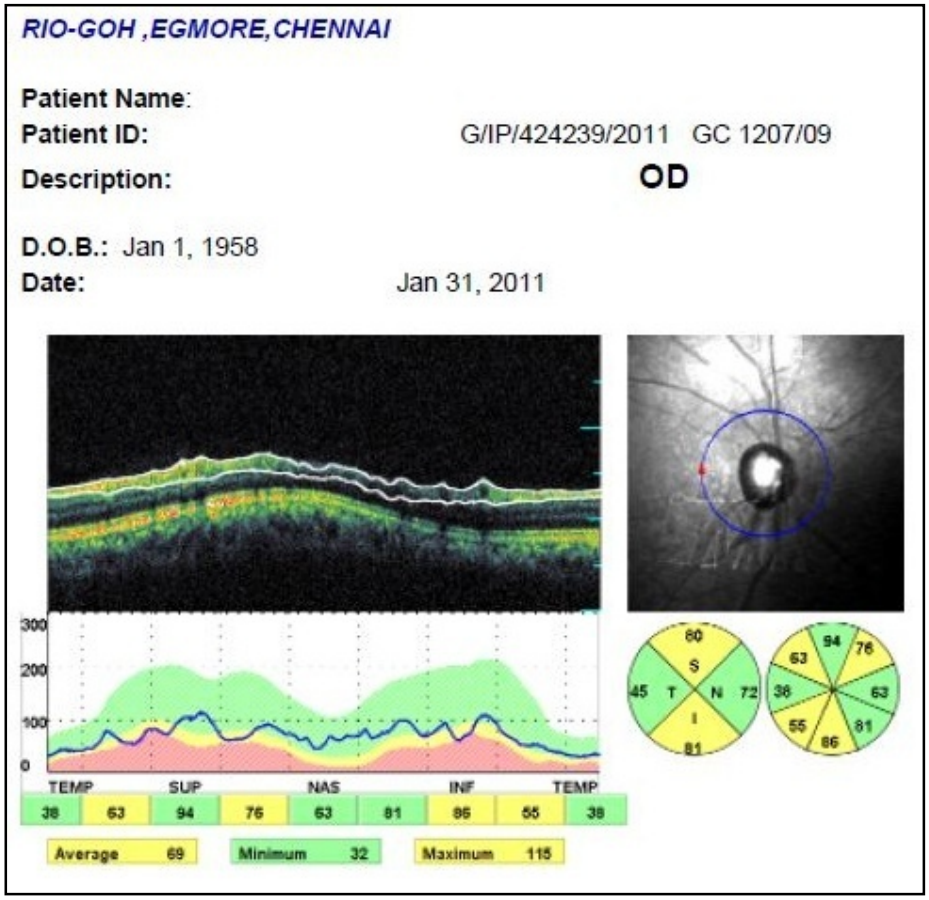


Figure 30. RNFL analysis by OCT showing thinning of the superior and inferior RNFL.



DISCUSSION

In order to compare the success rates of trabeculectomy and trabeculectomy with a collagen implant, patients who satisfied the eligibility criteria were enrolled. They were grouped into two and underwent either trabeculectomy or trabeculectomy with a collagen implant. Ocular parameters like Visual Acuity, intra-ocular pressure, C:D ratio of the ONH, Loss Variance by AP and RNFL thickness by OCT were monitored in the follow-up period.

Statistical comparison of the results was performed both within the groups and between the groups to find out the significance of changes in the ocular parameters.
In our study, 31 patients (81%) were above the age of 40. They were equally distributed between the groups. 5 patients with juvenile glaucoma were also enrolled as surgery was required in view of advanced glaucomatous damage.

Males and Females were equally distributed in the trabeculectomy group (50% each). In the group which had the OloGen implant, 65% were males and 35% were females. However, the Chi square test did not show any significant difference between the groups (p value of 0.62).

Most patients included in the study (35 out of 39 patients) had an uncontrolled IOP of >21 mm of Hg in spite of medical therapy. 10% of patients needed surgery

though they had IOP in the range of 16 to 20 mm of Hg as the ONH damage and field loss was advanced.

The central corneal thickness was between 501 and 600 microns in 81% of patients. For all patients, CCT corrected IOP was taken into consideration for the purpose of statistical analysis.

Automated perimetry analysis of the visual fields and OCT for the RNFL thickness was done on all patients. Some patients could not perform these tests owing to poor vision due to the disease process.

The ONH C:D ratio was estimated using the direct ophthalmoscope and it was seen that a majority of those needing surgery had advanced glaucomatous cupping (30% patients in the trabeculectomy group and 32% in the trabeculectomy with OloGen group).

One patient for whom trabeculectomy with the OloGen implant was performed in both eyes was lost to follow-up after the 3rd month of surgery. This patient was excluded from further analysis.

After trabeculectomy, the mean drop in IOP of 8.61 mm of Hg was observed at the end of a two year follow up. This was statistically significant with a p value of <0.001. The cup: disc ratio was also significantly different with a p value of 0.016.

Despite improvement in the above parameters, the drop in RNFL thickness was significant with a p value of 0.05. Measurement of LV did not show any significant difference.

In contrast, the group which underwent trabeculectomy with a collagen implant did not show any significant difference in the C:D ratio, LV by AP nor RNFL thickness. However, the IOP showed a significant drop of 12.96 mm of Hg. Analysis revealed a p value of <0.001 for the drop in IOP.

Comparing the outcomes of surgery in the two groups, there was a mean difference of 5.01 mm of Hg at the first week. This showed a significantly higher IOP in the implant group (p value of 0.020). this was attributed to the mechanical effect of the implant and its hygroscopic swelling in the sub-conjunctival region. The process of implant degradation and integration takes a period of around 6 months. Thereafter, the IOP at 1 year and 2 years had a mean difference of 3.42 and 4.38 respectively. This showed a significant drop of IOP in the collagen implant group (p values of 0.019 and 0.001 respectively).

Subsequent comparisons of the C:D ratio, loss variance and the RNFL thickness between the two groups did not show any difference either before surgery or at any stage of follow-up

In our study, though visual acuity did change, the effect of surgery on this parameter did not show any difference between the two groups as can be seen from the p value of 0.83 derived by the Chi square test.

Grading of the blebs by the Moorefields Bleb Grading System (MBGS) showed that when compared to the trabeculectomy group which had flat blebs, those in the trabeculectomy with OloGen group had larger and more diffuse blebs. In terms of bleb and conjunctival vascularisation, both groups were similar.

Applying the criteria for success, 45% of eyes (9 eyes) in the trabeculectomy group and 65% of eyes (11 eyes) in the trabeculectomy with collagen implant group were deemed to have attained complete success. Addition of topical agents or re-surgery enabled 25% of eyes in the trabeculectomy group and 17.6% of eyes in the trabeculectomy with collagen implant group to qualify as having had a successful outcome.

On looking into the complications encountered in the trabeculectomy with collagen implant group, allergic reactions were most common (23.5% of eyes). Two large overhanging blebs and 3 encysted blebs were also seen.

CONCLUSION

Trabeculectomy has traditionally been considered the gold standard surgery for glaucoma. Any new modality is always compared to trabeculectomy in terms of efficacy and complications. In spite of the coveted status it enjoys, trabeculectomy has its own limitations. Most surgeons find that trabeculectomy tends to fail over a course of time. This is primarily because of scarring of the bleb and the adjacent conjunctiva. The novel bio-integrable collagen implant regulates the process of bleb formation. It provides a framework for orderly deposition of collagen and hence ensures minimal scarring and bleb disorganization.

In our study, we have described and compared the results of trabeculectomy surgery performed on 20 patients and trabeculectomy surgery with Ologen implant performed on 19 patients. At the end of a two year follow-up, though the drop in IOP in both groups was significant, sustained low levels were achieved more often in patients who had the collagen implant. Moreover, other ocular parameters suggestive of glaucoma progression like increase in the loss variance on automated perimetry or thinning of the retinal nerve fiber layer were not encountered.

Bleb morphology tends to be favourably altered with the use of the implant as can be seen with use of the Moorefields bleb grading system. At the end of a two year follow up period, more number of eyes in the implant group maintained the complete

success of surgery. Some patients showed adverse reactions to the implant. Nevertheless, serious complications like bleb leak and blebitis were not seen.

The collagen implant can hence be use as a safe additive to the trabeculectomy surgery since it enhances the results of the procedure without any serious ocular effects directly attributable to the implant. As all steps of surgery are essentially the same as trabeculectomy, surgeons can carry out the procedure confidently to better the outcomes of their surgery in the long run.

FUTURE SCOPE

Our study comparing the surgical outcomes of trabeculectomy with and without the OloGen implant has showed that the collagen implant does play a positive role in maintaining the bleb architecture for the follow-up period of two years. However, since it is believed that the main advantage of using the collagen implant is the bleb maintenance for a long term, we need a longer follow-up to provide conclusive evidence of its efficacy. Studies that compare the results of trabeculectomy with collagen implants and antimetabolites could shed more light into the domain of long term maintenance of bleb architecture since both of them act as wound modulants albeit in different mechanisms.

REFERENCES

1. Duke-Elder's, System of Ophthalmology, The Anatomy of the Visual system, Vol 11, 1961; 101 - 286
2. R Stamper, M Liebermann, Becker – Shaffer's, Diagnosis and Therapy of the Glaucomas, 8th edition, 2009.
3. Allingham Rand, Karim Damji, Shields Textbook of Glaucoma, 6th Edition, 2011
4. Gabelt, Kaufman, et al, Adler's physiology of the eye, 3rd ed, 2003; 326 - 568
5. Tasman W, Jaeger, Duane's Foundations of Clinical Ophthalmology, 1995
6. Myron Yanoff, Jay S Duker, Ophthalmology, 2nd ed, 2004, Vol 2; 1411 – 1634.
7. Sommer, JM Tielsch, The Baltimore Eye Survey, Arch Ophthalmol, 1991; 109: 1090-5.
8. A Heijl, MC Leske, Reduction of intraocular pressure and glaucoma progression, Arch Ophthalmol, 2002; 120: 1268-79.
9. L E Pablo, A Ferreras, ONH changes in early glaucoma: a comparison between stereophotographs and HRT, Eye, 2010 ; 24: 123–130
10. Bengtsson, Heijl, A visual field index for calculation of glaucoma progression, American Journal of Ophthalmology. 2008; 145: 343-53
11. F W Fitzke, R A Hitchings, et al, Analysis of visual field progression in glaucoma. British Journal of Ophthalmology, 1996; 80: 40–48

12. Medeiros FA, et al, Comparison of the GDx VCC SLP, HRT II CSLO and the Stratus OCT for Glaucoma detection, Arch Ophthalmol, 2004; 122: 827-837
13. L Vijaya, P Manish, Management of complications in glaucoma surgery- an Indian perspective, Indian Journal of Ophthalmology. 2011; 59: 131–140
14. T Sharaawy, S Bhartiya, Surgical management of glaucoma: evolving paradigms, Indian Journal of Ophthalmology. 2011; 59: 123-30
15. MC Leske, A Heijl, Early Manifest Glaucoma Trial, Ophthalmology, 1999; 106: 2144-53.
16. MA Kass, DK Heuer, et al, The Ocular Hypertension Treatment Study- a randomized trial to determine if the topical ocular hypotensive medication delays or prevents the onset of primary open-angle glaucoma, Archives of Ophthalmology, 2002; 120: 701-13
17. The Advanced Glaucoma Intervention Study (AGIS), American Journal of Ophthalmology, 2000; 130: 429-40.
18. Thomas R, Braganza A, Chandrasekhar G, et al, The role of artificial drainage devices in glaucoma surgery, Indian Journal of Ophthalmology, 1998, Vol 46, 1: 41-46
19. NN Sood, Harsh Kumar, Role of 5 fluorouracil in the management of failed glaucoma surgery, Indian Journal of Ophthalmology, 1990, Vol 38; 1: 17-19
20. Ramakrishnan, M Khurana, Surgical management of glaucoma: An Indian perspective, Indian Journal of Ophthalmology, 2011, Vol 59, 7: 118-122.

21. A Mermoud, CS Corinne, Comparison of deep sclerectomy with collagen implant and trabeculectomy in open-angle glaucoma, Journal of Cataract & Refractive Surgery, Vol 25, 1999; 3: 323–331
22. Marc K, Sanchez E, Deep sclerectomy with collagen implant, British Journal of Ophthalmology, 1999; 83: 6-11.
23. Reproducibility of nerve fibre layer thickness measurements by use of optical Coherence tomography, Ophthalmology, 2000; 107: 2278-2282.
24. Papaconstantinou, Georgalas, E Karmiris, A Diagourtas, et al, Trabeculectomy with collagen implant versus trabeculectomy for the treatment of glaucoma, Acta Ophthalmologica, 2010; 88: 80-85.
25. Martini, Laffi , Sprovieri, Low-dosage mitomycin C as an adjunct to trabeculectomy, A prospective controlled study. European Journal of Ophthalmology, 1997; 7: 40-48.
26. Aptel , S Dumas, et al, Ultrasound biomicroscopy and optical coherence tomography imaging of filtering blebs after deep sclerectomy with new collagen implant, European Journal of Ophthalmology, 2009; 19: 223-230.
27. Rosentreter , A Schild , F Jordan, et al. A prospective randomised trial of trabeculectomy using mitomycin C vs an ologen implant in open angle glaucoma. Eye, 24, 1449–1457.
28. Lim, D S Allan, W Lloyd, et al, Glaucoma drainage devices: past, present and the future, British Journal of Ophthalmology 1998; 82 : 1083 – 1089.
29. T S Dietlin, G K Krieglstin, et al, Modern concepts in antiglaucomatous implant surgery, Graefes Arch Ophthalmology 2008; 246 : 1653 – 64.

30. Zelfskey R, Hsu W C, et al, Biodegradable collagen implant matrix for trabeculectomy, Expert Rev of Ophthalmology, 2008; 3 : 613 -17.
31. Tanuj Dada, K Rakhi, Shweta J B, et al, Trabeculectomy and Combined Use of Subconjunctival Collagen Implant with Low dose MMC, Journal of Glaucoma 2012; 10

TRABECULECTOMY WITH COLLAGEN IMPLANT GROUP

S. NO	NAME	AGE	SEX	DIAGNOSIS	EYE	AT PRESENTATION							SURGERY	1ST WEEK			1ST MONTH			3RD MONTH			6TH MONTH						1ST YEAR						2ND YEAR						REMARKS
						VA	IOP	CT	CD	GONIO	AP LV	RNFL		VA	IOP	C:D	VA	IOP	C:D	VA	IOP	C:D	VA	IOP	C:D	GONIO	LV	OCT	VA	IOP	C:D	GONIO	LV	OCT	VA	IOP	C:D	GONIO	LV	OCT	
1	GOVINDANAIDU	62	M	BE POAG	RE	PL	26	555	0.9	II/II/II/I	_	83	RE AG & O	PL	24	0.9	PL	22	0.9	PL	20	0.9	PL	20	0.9	II/II/II/II	_	85	PL	19	0.9	II/II/II/II	_	85	PL	20	0.9	II/II/II/II	_	87	
2	MOHAN	29	M	BE POAG	LE	1/60 NIP	16	573	0.9	III/III/III/III	_	-	LE AG & O	5/60 NIP	32	0.9	6/60 NIP	25	0.9	6/60 NIP	24	0.9	6/60 NIP	20	0.9	III/III/III/III	_	-	6/60 NIP	22	0.9	III/III/III/III	_	-	6/60 NIP	22	0.9	III/III/III/III	_	_	MMT
3	S.MUTHU	57	M	BE POAG	RE	6/9 PH 6/6	34	536	0.9	II/II/II/II	43.3	77	RE AG & O	6/12 PH 6/9	18	0.9	6/12 PH 6/9	17	0.9	6/12 PH 6/9	16	0.9	6/12 PH 6/9	19	0.9	II/II/II/II	54	76	6/12 PH 6/9	20	0.9	II/II/II/II	39.4	75	6/9 PH 6/6	20	0.9	II/II/II/II	27	74	MT, MTF
4	SETHURAMAN	59	M	BE PACG	RE	6/36 PH 6/18	32	512	0.7	II/II/II/III	12.2	126	RE AG & O	6/60 NIP	30	0.7	6/36 PH 6/18	26	0.7	6/36 PH 6/18	24	0.7	6/36 PH 6/18	20	0.7	II/II/II/III	13	128	6/36 PH 6/18	16	0.7	II/II/II/III	14.4	129	6/24 PH 6/12	16	0.7	II/II/II/III	15	132	
5	RAMANI	59	M	BE PACG	RE	6/60 PH 6/36	36	519	0.5	I/I/I/CL	14.7	121	RE AG & O	6/60 NIP	26	0.5	6/60 NIP	24	0.5	6/60 PH 6/36	20	0.5	6/60 PH 6/36	19	0.5	I/I/I/CL	4.4	123	6/60 PH 6/36	18	0.5	I/I/I/CL	6.6	119	6/60 PH 6/36	18	0.5	I/I/I/CL	7.5	121	
6	SWAMINATHAN	51	M	BE POAG	LE	6/36 PH 6/24P	42	578	0.7	III/III/II/III	12.2	108	LE AG & O	6/36 P NIP	30	0.7	6/36 PH 6/24P	32	0.7	6/36 PH 6/18P	32	0.7	6/36 PH 6/18P	26	0.7	III/III/II/III	13	106	6/36 PH 6/18P	21	0.7	III/III/II/III	8.6	105	6/36 PH 6/24P	19	0.7	III/III/II/III	7.2	106	
7	GOVINDHASWAMY	63	M	RE PACG	RE	6/24 PH 6/18P	23	522	0.8	CL/CL/I/I	35.3	135	RE AG & O	6/60 PH 6/36P	17	0.8	6/60 PH 6/36P	18	0.8	6/36 PH 6/18	16	0.8	6/36 PH 6/18	18	0.8	CL/CL/I/I	28	132	6/36 PH 6/18	18	0.8	CL/CL/I/I	15.7	126	6/36 PH 6/24	16	0.8	CL/CL/I/I	9.8	128	
8	MADHAN MOHAN	34	M	BE PACG	RE	6/18P NIP	46	581	0.4	CL/I/CL/I	6.9	114	RE AG & O	6/24P PH 6/24	34	0.4	6/18P NIP	26	0.4	6/18 PH 6/9	22	0.4	6/18 PH 6/9	16	0.4	CL/I/CL/I	8.9	112	6/18 PH 6/9	17	0.4	CL/I/CL/I	20.8	110	6/18 PH 6/9	23	0.5	CL/I/CL/I	17	113	MT, RE TR
9	KAVITHA	43	F	BE POAG	LE	6/12 PH 6/9	28	487	0.8	II/II/III/II	37.7	93	LE AG & O	6/18 NIP	24	0.8	6/18 NIP	20	0.8	6/18 PH 6/12P	17	0.8	6/18 PH 6/12P	14	0.8	II/II/III/II	22	94	6/18 PH 6/12P	15	0.8	II/II/III/II	18	95	6/18 PH 6/12P	14	0.8	II/II/III/II	26	94	

10	RAJESHWARI	68	F	BE PACG	RE	6/24 PH 6/12	25	503	0.6	I/I/I/CL	7.3	127	RE AG & O	6/36P PH 6/18	26	0.6	6/36 NIP	2	0.6	6/36 PH 6/24	18	0.6	6/36 PH 6/24	22	0.6	I/I/I/CL	8.8	128	6/36 PH 6/24	20	0.6	I/I/I/CL	10.4	124	6/36 PH 6/24	21	0.7	I/I/I/CL	6.8	124	
11	RASIYA	49	F	BE PACG	LE	6/12 NIP	24	501	0.9	CL/CL/I/II	21.5	112	LE AG & O	6/24 PH 6/12	22	0.9	6/18 PH 6/9	18	0.9	6/18 PH 6/9	12	0.9	6/18 PH 6/9	16	0.9	CL/CL/I/II	23	110	6/18 PH 6/9	16	0.9	CL/CL/I/II	34.6	116	6/18 PH 6/9	18	0.9	CL/CL/I/II	29	112	
12	NAYAGAM	55	F	BE PACG	LE	6/9 PH 6/6	20	560	0.9	CL/CL/CL/I	85.1	95	LE AG & O	2/60 NIP	16	0.9	3/60 NIP	16	0.9	6/24 PH 6/18	14	0.9	6/24 PH 6/18	14	0.9	CL/CL/CL/I	44	94	6/18 PH 6/9	15	0.9	CL/CL/I/I	54	94	6/12 PH 6/6P	12	0.9	CL/CL/I/I	48	95	
13	FRANCIS	42	M	RE JG	RE	6/12 PH 6/9	32	500	0.7	III/IV/IV/III	15.6	100	RE AG & O	6/24 NIP	27	0.7	6/24 PH 6/18	29	0.7	6/24 PH 6/12	16	0.7	6/24 PH 6/12	12	0.7	II/III/III/II	7.2	106	6/24 PH 6/12	10	0.7	II/III/III/II	8.1	104	6/12 PH 6/6P	14	0.7	II/III/III/II	8.4	104	MT, REV
14	SUMATHY	33	F	BE PACG	RE	6/18 PH 6/12P	40	507	0.8	II/I/I/I	24.6	-	RE AG & O	6/18 PH 6/9	28	0.8	6/18 PH 6/6	28	0.8	6/18 PH 6/9	16	0.9	6/12 PH 6/6	13	0.9	II/I/I/I	13	-	6/9 PH 6/6	14	0.9	II/I/I/I	16.5	-	6/12 PH 6/6	16	0.9	II/II/I/I	7.7	-	MT, MTF
15	JAMUNA	48	F	BE POAG	LE	6/60 PH 6/24P	30	505	0.8	II/III/III/III	35.2	79	LE AG & O	6/12 PH 6/9	14	0.8	6/24 PH 6/18	13	0.8	6/12 PH 6/9	12	0.8	6/12 PH 6/9	15	0.8	II/III/II/III	12	75	6/12 PH 6/9	14	0.8	II/III/II/III	16.2	79	6/12 NIP	12	0.8	II/II/II/III	6.9	82	
16	JAMUNA	48	F	BE POAG	RE	6/12 PH 6/9	25	510	0.8	III/III/III/III	44.9	77	RE AG & O	6/18 PH 6/6	12	0.8	6/9P NIP	14	0.8	6/9P NIP	14	0.8	6/9P NIP	12	0.8	III/III/III/III	26	82	6/9P PH 6/6P	16	0.8	III/II/II/II	22.2	82	6/9P PH 6/6P	14	0.8	III/II/II/II	16	86	
17	GOWRI	38	F	BE CG	LE	6/36 PH 6/18	26	534	0.9	III/III/III/III	8.1	-	LE AG & O	6/60 PH 6/36	28	0.9	6/60 PH 6/24P	35	0.9	6/36P PH 6/24	38	0.9	6/36 PH 6/18	26	0.9	III/III/III/III	9.3	-	6/36 PH 6/18	21	0.9	III/III/II/II	14.5	-	6/36 PH 6/18	21	0.9	III/III/II/II	10	_	MMT
18	TAMILARASAN	14	M	BE CG	RE	6/60 NIP	24	610	0.5	II/II/II/II	_	-	RE AG & O	6/60 NIP	26	0.5	6/60 PH 6/36P	18	0.5	6/36P NIP	20	0.5	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	LOST TO FOLLOW UP
19	TAMILARASAN	14	M	BE CG	LE	6/60 PH 6/36	34	625	0.8	II/II/II/I	_	-	LE AG & O	6/60 NIP	28	0.8	6/36 PH 6/24	16	0.8	6/36 PH 6/24P	18	0.8	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	_	LOST TO FOLLOW UP

\

TRABECULECTOMY GROUP

S. NO	NAME	AGE	SEX	DIAGNOSIS	EYE	AT PRESENTATION							SURGERY	1ST WEEK			1ST MONTH			3RD MONTH			6TH MONTH						1ST YEAR						2ND YEAR						REMARKS
						VA	IOP	CT	CD	GONIO	LV	RNFL		VA	IOP	C:D	VA	IOP	C:D	VA	IOP	C:D	VA	IOP	C:D	GONIO	LV	OCT	VA	IOP	C:D	GONIO	LV	OCT	VA	IOP	C:D	GONIO	LV	OCT	
1	RAMALINGAM	60	M	BE PACG	LE	2/60 NIP	48	510	0.8	I/I/I/I	_	78	LE AG	1/60 NIP	22	0.8	2/60 NIP	16	0.8	2/60 NIP	25	0.8	2/60 NIP	28	0.9	I/CL/I/I	_	75	2/60 NIP	28	0.9	I/CL/I/I	_	72	2/60 NIP	30	0.9	I/I/I/I	_	72	MMT
2	RAVI	55	M	BE PACG	LE	6/36 PH 6/9	37	578	0.4	CL/CL/I/I	7.7	112	LE AG	6/60 NIP	36	0.4	6/60 NIP	20	0.4	6/60 NIP	18	0.4	6/36NIP	18	0.4	CL/CL/I/I	11	110	6/36 NIP	18	0.4	CL/CL/I/I	13.4	105	6/36 PH 6/24	18	0.5	CL/I/I/I	24	100	
3	VIJAYAKUMAR	32	M	BE POAG	RE	6/60 NIP	38	532	0.9	II/II/IV/II	_	83	RE AG	4/60 NIP	18	0.9	6/60 NIP	20	0.9	6/60 NIP	22	0.9	6/60 NIP	21	0.9	II/II/II/II	_	84	6/60 NIP	22	0.9	II/II/II/II	_	80	6/60 NIP	17	0.9	II/II/II/II	_	79	MT, RE TR
4	KAMALA	62	F	BE POAG	LE	6/36 PH 6/12	25	502	0.8	III/III/III/III	27.6	108	LE AG	5/60 PH 6/60	15	0.8	6/36 PH 6/12	18	0.8	6/36 PH 6/12	20	0.8	6/36 PH 6/12	18	0.8	III/III/III/III	21	110	6/36 PH 6/12	20	0.8	III/III/III/III	16.2	105	6/36 PH 6/12	21	0.8	III/III/III/III	30	105	
5	KAMALA	62	F	BE POAG	RE	6/18 PH 6/12	27	505	0.9	III/II/III/II	8.9	114	RE AG	6/36 NIP	22	0.9	6/36 NIP	20	0.9	6/36 PH 6/24P	17	0.9	6/36 PH 6/18	16	0.9	III/II/III/II	17	116	6/36 PH 6/18	17	0.9	III/II/III/II	11.1	113	6/36 NIP	21	0.9	III/II/II/II	9.7	111	
6	SUSEELA	67	F	BE PACG	LE	6/36 NIP	42	536	O.5	CL/I/CL/I	6.5	119	LE AG	2/60 NIP	16	0.5	3/60 NIP	17	0.5	6/60 NIP	14	0.5	6/60 NIP 6/36	16	0.5	CL/I/CL/I	5.1	120	6/60 PH 6/36	18	0.5	CL/I//CL/I/	7.5	118	6/36 NIP	19	0.5	CL/I/CL/I	10	118	
7	MANI	54	M	RE POAG	RE	6/36P PH 6/18	39	511	0.8	III/III/III/III	81.3	128	RE AG	6/60P NIP	25	0.8	6/60 NIP	22	0.8	6/60 PH 6/36	20	0.8	6/60 PH 6/36	22	0.8	III/III/III/III	65	126	6/60 NIP	20	0.8	II/III/III/II	60.4	124	6/60 NIP	20	0.8	II/III/III/II	49	125	MT
8	RAMALINGAM	57	M	BE PACG	RE	6/36 PH 6/18P	34	571	0.9	I/I/I/I	29.8	103	RE AG	6/36 NIP	15	0.9	6/36 NIP	17	0.9	6/36 PH 6/18	17	0.9	6/36 PH 6/18	18	0.9	I/I/I/I	12	-	6/36 NIP	19	0.9	I/I/I/I	15.2	99	6/36 NIP	18	0.9	I/I/I/I	18	97	
9	RAMALINGAM	57	M	BE PACG	LE	6/60 PH 6/24P	28	559	0.9	CL/I/I/CL	19.9	116	LE AG	6/60 PH 6/36	13	0.9	6/60 PH 6/36	13	0.9	6/36 NIP	14	0.9	6/36 P PH 6/24	14	0.9	CL/I/I/CL	11	113	6/36 PH 6/24	16	0.9	CL/I/I/CL	6.5	114	6/36 NIP	16	0.9	CL/CL/CL/I	8.2	109	

10	APARUPAM	47	F	BE POAG	RE	6/12 PH 6/9	20	496	0.7	II/II/II/I	26.4	117	RE AG	6/36 PH 6/24	12	0.7	6/36 NIP	12	0.7	6/24 PH 6/9P	14	0.7	6/12 NIP	14	0.7	II/II/II/II	18	115	6/12 NIP	12	0.7	II/II/II/I	12.6	115	6/12 PH 6/9	12	0.7	II/II/II/II	20	114	
11	THANGAVEL	69	M	BE POAG`	RE	6/24 PH 6/12	26	525	0.8	II/II/III/II	18.2	109	RE AG	6/24 NIP	18	0.8	6/24 PH 6/9	17	0.8	6/24 PH 6/9	15	0.8	6/24 PH 6/9	24	0.8	II/II/III/II	7.4	110	6/24 PH 6/9	22	0.8	II/II/III/II	8.5	107	6/24 PH 6/9	23	0.8	II/I/III/Ii	15	106	MMT
12	KASTHURI	57	F	BE POAG	LE	6/9 PH 6/6	16	550	0.6	III/II/III/II	5.3	85	LE AG	6/24 PH 6/18P	10	0.6	6/24 PH 6/9	12	0.6	6/9 NIP	12	0.6	6/9 PH 6/6	23	0.7	III/II/III/II	8.1	85	6/9 PH 6/6	13	0.7	III/II/II/III	6.2	82	6/9 PH 6/6	14	0.6	III/III/II/II	5.6	86	MT, RE TR
13	KATHISHA BEEVI	55	F	BE PACG	RE	3/60 NIP	22	587	0.9	I/I/CL/I	39.1	-	RE AG	3/60 NIP	17	0.9	3/60 NIP	18	0.9	3/60 NIP	16	0.9	3/60 NIP	17	0.9	I/I/CL/I	21	_	5/60 NIP	22	0.9	I/I/CL/I	20.6	_	6/60 NIP	24	0.9	I/I/CL/I	23	_	MT, RE TR
14	AROKIANATHAN	54	M	BE PACG	RE	6/18 NIP	21	605	0.8	CL/CL/I/CL	8.2	76	RE AG	6/24 PH 6/18	12	0.8	6/36 PH 6/24	13	0.8	6/36 PH 6/24P	13	0.8	6/18 PH 6/12	20	0.8	CL/CL/CL/I	4.2	74	6/18 NIP	24	0.8	CL/CL/I/CL	5.8	79	6/18 PH 6/9	26	0.8	CL/CL/I/CL	7.5	82	MT, RE TR
15	MALA	58	F	BE PACG	RE	6/60 PH 6/36	27	534	0.5	CL/CL/I/I	7.1	89	RE AG	6/36 NIP	18	0.5	6/60 PH 6/36	18	0.5	6/60 PH 6/36	25	0.5	6/60 PH 6/36	25	0.5	CL/CL/I/I	11	89	6/60 PH 6/36	26	0.5	CL/CL/CI/I	13.2	96	6/36 PH 6/24	24	0.6	CL/CL/I/I	12	97	MMT
16	VASANTHAKUMARI	48	F	BE PACG	LE	6/18 PH 6/6	24	570	0.8	I/CL/II/CL	43.7	125	LE AG	6/24 PH 6/18	20	0.8	6/18 PH 6/6	19	0.8	6/18 PH 6/6	21	0.8	6/18 PH 6/6	20	0.8	I/CL/II/CL	37	126	6/18 PH 6/6	20	0.8	I/CL/II/CL	19.6	125	6/18 PH 6/6	21	0.8	I/CL/II/CL	14	128	MT, MTF
17	VANI	55	F	BE POAG	RE	6/24 PH 6/12	25	564	0.9	II/II/II/II	33.8	86	RE AG	6/36 PH 6/24P	14	0.9	6/24 PH 6/12	14	0.9	6/24 PH 6/12	16	0.9	6/24 PH 6/12	16	0.9	II/II/II/II	46	84	6/18P NIP	19	0.9	II/II/III/II	32.3	83	6/18P NIP	20	0.9	II/II/II/II	28	83	
18	PARASARURAMAN	49	M	BE POAG`	RE	4/60 NIP	34	497	0.7	III/III/IV/III	_	120	RE AG	3/60 NIP	30	0.7	6/60 NIP	26	0.7	6/60 NIP	22	0.7	6/60 NIP	20	0.7	III/III/IV/III	_	118	6/60 NIP	20	0.7	III/III/III/III	_	120	6/60 NIP	21	0.7	III/III/III/III	_	126	MT
19	MADHAVAN	26	M	RE JUVENILE GLAUCOMA	RE	6/24 PH 6/18	32	564	0.8	III/II/III/II	21.2	78	RE AG	6/24 PH 6/18P	16	0.8	6/24 PH 6/18P	16	0.8	6/24 PH 6/18P	18	0.8	6/24 PH 6/18P	20	0.8	III/II/III/II	14	82	6/24 PH 6/18P	20	0.8	III/II/II/III	16.5	82	6/12 NIP	20	0.8	III/III/II/II	23	83	
20	JEYASUDHA	12	F	BE CONGENITAL GLAUCOMA	LE	6/60 NIP	28	597	0.7	III/III/IV/III	_	118	LE AG	3/60 NIP	15	0.7	4/60 NIP	15	0.7	3/60 NIP	25	0.7	4/60 PH 6/60	22	0.7	III/III/IV/III	_	115	4/60 PH 6/60	22	0.7	III/IV/III/IV	_	110	6/60 PH 6/36	22	0.8	III/III/IV/III	_	116	MMT

turnitin

Your digital receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

Paper ID	287559466
Paper title	AN ANALYTICAL STUDY OF THE SURGICAL OUTCOMES OF TRABECULECTOMY WITH AND WITHOUT OLOGEN IMPLANTS
Assignment title	Medical
Author	Madanagopalan 22101804 M.S. Ophthalmology
E-mail	metzeles@yahoo.com.au
Submission time	21-Dec-2012 06:19PM
Total words	13736

First 100 words of your submission

Dissertation on AN ANALYTICAL STUDY OF THE SURGICAL OUTCOMES OF TRABECULECTOMY WITH AND WITHOUT COLLAGEN IMPLANTS Submitted in partial fulfillment of requirements of M.S. OPHTHALMOLOGY BRANCH – III REGIONAL INSTITUTE OF OPHTHALMOLOGY MADRAS MEDICAL COLLEGE CHENNAI – 600 003 THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY CHENNAI APRIL 2013 INTRODUCTION Glaucoma is a leading cause of irreversible blindness throughout the world. The modern understanding of the disease dates back to the mid- 19 th century. However, this disease was recognised by the Greeks and Hippocrates refers to the entity as “glaucosis”. World Health Organisation statistics indicate that glaucoma accounts for 13.5% of global...